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ABSTRACT

Using data from the 1960-1977 period, this study provides a range of headcount enrollment projections for the Michigan higher education system to the year 2000 by type of institution and by age and sex of student under alternative sets of projection assumptions. The theoretical framework, methodology, and working model developed in this study are designed to reduce the uncertainty associated with long-run forecasts of the demand for higher education and provide a tool that will be of continuing use to the planning community. Enrollment is predicted by examining two factors. First is the complex economic and demographic phenomena that jointly determine the size and distribution of the population pool feeding higher education. Second is the network of environmental and behavioral relationships that determine participation rates in higher education. The study concludes that enrollment will peak in the late 1970's, remain essentially stable through the early 1980's, and then decline steadily until the mid-to-late 1990's. Other conclusions drawn by the study suggest that four-year institutions will fare slightly better than two-year schools and female enrollments will grow relative to males. Tables include statistical information on economic projections, enrollment patterns, structural equations, and exogenous variables. Three appendices are provided: Structural Equations and Variable Definitions; Demographic Methodology; and Household Demand for Higher Education. A bibliography is provided. (LC)

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# THE DEMAND FOR HIGHER EDUCATION IN MICHIGAN: PROJECTIONS TO THE YEAR 2000

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## PUBLISHER'S NOTE

The Presidents Council is pleased to publish this research report on higher education enrollment projections by Dr. James L. Moor, Jr., of Central Michigan University. The Moor study is a special piece of work. Those concerned with the discipline of method will find it designed and executed with meticulous care. Those whose focus is primarily on substance will find it a valuable source of information. All who are professionally engaged in higher education planning will find here an innovative tool to enhance the precision of their profession.

Dr. Moor has focused on long-range forecasting of demand for higher education services in Michigan. In the process he has created a highly sensitive and versatile model with the capability for application in other states and regions. The innovations in forecasting here are particularly timely, and welcome, as all of us who are concerned with the future of higher education seek a clearer and more reliable vision of the variables which will shape that future.

This study was first brought to our attention by our colleague Dr. Harold Abel, President of Central Michigan University. We recommend it to you as enthusiastically as Dr. Abel recommended it to us. We have brought the report to print because it is a first-rate study which deserves the attention of all who might benefit from it.

January 1979

## SUMMARY: RESEARCH GOALS AND RESULTS

The purpose of this study is to project enrollments in Michigan's system of higher education for the remainder of the century. These projections are intended to provide useful input to the various agencies and institutions which must plan and make policy for the future. Expectations concerning that future will, in turn, set the mood and influence the emphasis for public and private planning in higher education for the next two decades. The theoretical framework, methodology, and working model developed in this study will reduce, hopefully, the uncertainty associated with long-run forecasts of the demand for higher education and provide a tool which will be of continuing use to the planning community.

In order to explain past enrollment patterns and to project future trends, one must deal with two separate but interrelated challenges, both of which are critical to the quality of the projections. First, it is necessary to model the complex economic and demographic phenomena which jointly determine the size and distribution of the population pool which feeds higher education--defined in this study as Michigan's 18-49 year-olds. The trend-demographic population forecasts most often utilized for estimating this pool are potentially flawed, because they fail to specifically account for the socio-economic determinants of gross and net migration flows. Migration is, at once, the most volatile component of regional population change and the only component that is of serious concern to the higher education planning process. In comparison, changes in birthrates, for example, can be observed nearly two decades prior to their impact on college enrollment.

This study utilizes an economic-demographic model which simultaneously predicts such key variables as income by industry, employment by industry, labor force, unemployment rates, population by age, race and sex, and migration flows.

Second, it is necessary to capture the equally complex network of environmental and behavioral relationships which determine participation rates in higher education. In other words, one must be able to predict what proportion of each age-, race-, and sex-specific sub-group of the 18-49 year-old population will choose to enroll. In this second step of the sequential research process, it is just as important to avoid casual modeling which accepts ad hoc explanations of human choice processes in isolation from the economic realities of alternative opportunities, relative price movements, public subsidies, changing tastes and shifting population distribution. Thus, the underlying and seemingly simple calculation--which multiplies the number of persons in the eligible population pool by a participation rate to yield the number of enrollees--becomes a sophisticated problem in economic-demographic modeling.

Beyond the challenge of finding an appropriate conceptual approach, there are a series of more practical problems. The theoretical model must be estimated, simulated, and projected using actual data. The region-specific data base is typically less than adequate with respect to both quantity and quality, and Michigan proves no exception to the general rule. Furthermore, behavior among different subgroups of higher education enrollees is quite dissimilar, in terms of both cause and effect. Males and females, whites and non-whites, traditional and non-traditional-age students exhibit notably

varied patterns of enrollment. Consequently the data base and the model alike must be highly disaggregated by age, race, and sex wherever possible. Last, because projecting the future requires forecasting certain external variables, such as the rate of national economic growth or government policy changes, no one set of projection assumptions is adequate to serve a diverse audience. Consequently, the model structure must be flexible enough to accept alternative sets of assumptions which can be easily and cheaply processed to yield a range of forecasts.

It is the author's hope that this work provides a reasonable although certainly far from perfect response to these challenges. Using data from the 1960-1977 period, the study provides a range of headcount enrollment projections to the year 2000 by type of institution and by age and sex of student under alternative sets of projection assumptions. The study concludes that enrollments will peak in the late 1970's, remain essentially stable through the early 1980's, and then decline steadily but not precipitously until the mid-to-late 1990's. The "most likely" range for maximum decline is predicted to be 15 to 20 percent for the entire system. Within this overall pattern of change, private and public four-year institutions tend to fare slightly better than the public two-year schools. Female enrollments grow relative to males, with female groups under thirty exhibiting the largest participation rate increases. On the other hand, participation rates on the part of students over thirty are projected to decline from their present all-time highs. Non-traditional student enrollment will remain at or near current levels, however, due to dramatic increases in the number of persons from 30-49 years old which will occur as the well-publicized "baby boom" continues to age.

The projections are annual forecasts of long-term trend and do not purport to predict the inevitable cyclical variations about trend that will occur from year to year in both the Michigan economy and the demand for higher education. The model developed in this study attempts to capture the complex economic-demographic factors which comprise the highly interactive environment within which higher education exists. Its usefullness will depend on how well it has identified the meaningful casual relationships which underlie the human behavior being modeled.

But surely no research effort can duplicate the complexities of real world behavior or anticipate fully the unexpected. Consequently, the usual caveat applies--those factors which have and will influence enrollment but are not explicitly treated by the study are implicitly assumed to remain constant. For example, this work neither anticipates substantial new programs for higher education nor any dramatic changes in the nature of public funding. The enrollment trends predicted here could be partially offset by new and more attractive services. Equally as well, they could be mandated or, indeed, exacerbated by reductions in funding, were those reductions to occur before rather than after the fact. In the end, therefore, it is the response of the "higher education system" to its own expectations about the future which will, in part, determine what is to come.

## ACKNOWLEDGEMENTS

This study is the culmination of nearly three years of work and would not have been possible without the support of Central Michigan University--especially its President, Dr. Harold Abel, and the Office of Instruction and Research--which provided the encouragement, basic resources and computer facilities that were essential to the completion of the project. My colleague, Darius Conger, was the co-author of the paper which served as the pilot study for this research. His advice and criticism throughout our association was invaluable and this study would be poorer without his contributions. Jack Mason, who has been my programmer and assistant on several regional modeling projects, expertly guided the computer through its paces and generated some key insights at moments of extreme frustration.

Of course, the author is solely responsible for all errors and omissions, and my views should in no way compromise the aforementioned. It is my hope that all who supported this research are pleased with the end-product and that the study's findings are useful to those charged with the arduous task of planning and policy-making in higher education.

TABLE OF CONTENTS


| | Page |
|---|---|
| Publisher's Note | ii |
| Summary: Research Goals and Results | iii |
| Acknowledgements | vii |
| List of Tables and Figures | ix |
| Introduction | 1 |
| Post-War Education Boom | 2 |
| Will The Education Boom Continue? | 5 |
| Alternative Methodologies | 8 |
| An Overview of The Study | 11 |
| The Economic Model | 13 |
| Economic-Demographic Projections | 21 |
| The Education Model | 35 |
| The Enrollment Projections | 56 |
| Conclusion | 66 |
| Appendices | |
| A. Structural Equations and Variable Definitions | 69 |
| B. Demographic Methodology | 81 |
| C. Household Demand For Higher Education | 90 |
| Bibliography | 99 |

## LIST OF TABLES AND CHARTS


Page

TABLE NO.

1 Historical Data and Projection Assumptions for Exogenous Variables: Economic Model. . . . . 24

2 Michigan Economic Projection Through 2000. . . . . 28

3 Michigan's Pool of Potential Enrollees in Higher Education . . . 34

4 Higher Education Participation Rates by Age and Sex, Michigan--1960-1977 . . . . . 38

5 Historical Enrollment Patterns: Michigan, 1960-1977 . . . . . 41

6 Historical Data for Exogenous Variables: Education Model. . . . 46

7 Structural Equations: Education Model . . . . . 50

8 Projection Assumptions for Exogenous Variables: Education Model . . . . . 57

9 Michigan Enrollment Projections Through 2000 . . . . . 61

Appendix Tables:

A-1 Definition of Variables. . . . . 70

A-2 Structural Equations: Economic Model. . . . . 75

A-3 Structural Equations: Education Model . . . . . 79

B-1 Percentage Deviation: Simulated Population Over/(Under) Actual Census Count - 1970 Population Matrix. . . . . 86

B-2 Net Migration and Labor Force Simulations: Actual vs Estimated--1960-1977. . . . . 88

B-3 Michigan Birthrate Experience and Projections. . . . . 89

CHART NO.

1 Aggregate Higher Education Participation Rate. . . . . 44

## INTRODUCTION

Higher education in the U. S. has been characterized by steady and often dramatic growth during the post-war period. This was especially true of the 1960's and 1970's to date, a period during which the number of institutions, enrollment, public investment, and employment in higher education increased year by year with only an occasional pause. As a nation, we spent only $2.1 billion on higher education in 1950 and $6.7 billion in 1960, as compared to $49.2 billion in 1977. This represents a steady increase in the percent of society's productive capacity devoted to higher education, from less than one percent of gross national product in 1950 to nearly three percent in 1977. Moreover, superimposed on this trend was a continually increasing share of public as opposed to private institutions and enrollment. In short, publicly-controlled institutions now generate more than 75 percent of enrollments in higher education and government provides 50 percent of the funding, including about 20 percent of the funds used by private institutions.[1]

As a consequence of seemingly unending growth, one of the more critical questions for educational planners and policy-makers is whether the post-war trends to date will continue, level-off, or decline through the 1980's and 1990's. Expectations concerning the answer to this question will set the mood and, in part, determine the emphasis for public and private planning in higher education through the remainder of this century. The purpose of this study is to provide a theoretical framework and an empirical model

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[1]The spending figures are taken from tables prepared by the U. S. National Center For Education Statistics and published in the Statistical Abstract of The United States.

which attempt to answer this question or, at least, to reduce the uncertainty associated with long-run enrollment forecasts for Michigan. The end-product includes a series of projections for enrollment in Michigan's higher education institutions through the year 2000. These projections conclude that the "climb" of the 1960's and 1970's is just about over and the late 1980's and 1990's will most likely bring moderate declines. Hopefully, the methodology developed here will be of continuing use to planners and policy makers as they try to anticipate the future.

## POST-WAR EDUCATION BOOM

Before detailing the theoretical and empirical design of the study, it will be useful to attempt to highlight some of the apparent causes of the post-war experience to date. The author would characterize a significant portion of the climb as a confluence of rather fortuitous events and circumstances, not likely to be duplicated again. The most notable of these was demographic--the so-called "baby boom" of the 1950's and early 1960's. Had everything else remained the same, this single factor would have led to steadily increasing enrollments until the early 1980's. If we delineate the baby-boom as 1947-1961,[2] then it will not be until 1983 that the last birth cohort[3] of that "boom" will reach twenty-two years of age. Following

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[2]The year 1961 began a steady decline in births in Michigan caused by a decline in the completed fertility rate from over 3.6 children per woman to under 1.8 children per woman by the mid-1970's, according to estimates by the Michigan Department of Public Health and the author.

[3]A "cohort" is a group of individuals who experienced the same demographic event (birth, death, marriage, etc.) during a specified, brief period of time, usually a year. In this study, the "birth cohort" is most often utilized, referring to persons born in the same year or period of years. As a consequence, these people are constantly in the same "age cohort" and can be subdivided according to other demographic characteristics such as race, sex, years of school completed, etc.

that cohort will be steadily declining numbers of those college-age persons who have exhibited the highest propensity to enroll in higher education, the 18 to 21 year olds. In contrast to the "baby boom," the "baby bust" continues in spite of some predictions to the contrary.[4] It must be recognized for purposes of planning in the remainder of the century that a new baby boom, should one occur, would have little impact on higher education until after the turn of the century.

The demographic bulge was not the only factor leading to increasing enrollments in the post-war period. Rising numbers of potential students were accompanied by changing societal values. Higher education, once the training ground for the elite, is now perceived by individuals and society alike as one method of enhancing the equality of opportunity.[5] These changing values were reinforced with legislation which instituted non-discrimination and affirmative-action policies and were augmented by a variety of direct subsidies to higher education adopted by both federal and state government. These subsidies, ranging from guaranteed loans to outright grants, lowered the net explicit price of higher education to the enrollee. One result was considerable educational widening and deepening, as traditional-age college students sought more education than before and non-traditional students increased their propensity to enroll.[6] Consequently,

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[4]See Table B-3 for additional information on birthrates.

[5]R. W. Fleming, "Reflections on Higher Education," Daedalus, Fall, 1975, p. 8.

[6]The terms "widening" and "deepening" come from Howard R. Bowen, "Teaching and Learning: 2000 A. D." New Directions In Higher Education, No. 42 (Winter, 1975), p. 3. For purposes of this study traditional-age college students will be considered to be from 18-24 years of age; non-traditional students from 25-49 years of age.

higher education participation rates[7] within cohorts increased simultaneously with the size of those cohorts.

Rising demand for higher education, especially publicly-subsidized education, put pressure on the supply side. The unusually strong economy of the 1960's, especially in Michigan which experienced an unprecedented economic boom fueled by rapid growth in automobile demand, allowed public investment in higher education to expand to satisfy rising enrollments. Existing facilities were expanded and the fiscal dividend of the 1960's facilitated the rapid development of a new low-cost, higher education institution--the public, two-year college. Two-year colleges, in turn, further augmented participation because their location and focus frequently allowed students to live at home and perhaps work as well; thus, not bear the higher explicit price of a four-year education. This confluence of enrollment-inducing economic events was buttressed by rapidly rising real per capita income, which brought students to college at all levels who had not heretofore considered higher education as an affordable alternative.

Therefore, enrollments would have surged in the 1960's and 1970's without the Vietnam experience, which precipitated even higher education participation rates among young, draft-age males who elected additional schooling over active duty. A new GI bill also entitled those who served to qualify for subsidized enrollment subsequent to the war. This study and others[8] demonstrate that both factors increased participation rates, the

[7]A "participation rate" is the proportion of a given cohort of people who choose to participate in a given activity or demand a given commodity. For example, higher education participation rates measure the proportion of given age- and sex-specific groups who enroll in college.

[8]See U. S. Bureau of the Census, Current Population Reports, Series P-20, "School Enrollment--Social and Economic Characteristics of Students (annual)," especially the October, 1976 report, No. 319 (Feb. 1978). Also see H. Galper and R. M. Dunn, Jr., "A Short-Run Demand Function for Higher Education in the United States," Journal of Political Economy, Vol. 77, No. 5 (Sept.-Oct., 1969) pp. 765-77.

former for 18-21 year-old males, the latter for older males, 25 years and over. Enrollment of males over thirty also grew because of a special provision in the bill which made interwar veterans (Korea-Vietnam) eligible for full education benefits until May, 1976.

Finally, U. S. labor markets were continuing to demand increasing numbers of college-educated labor. Through the 1960's, the demand for such labor exceeded the supply,[9] making higher education a good investment. Most studies covering this period concluded that the rate of return on a college education (a form of human capital) exceeded the rate of return on physical capital.[10] To reiterate then, the socio-economic circumstances which characterized the post-war period to date represented a confluence of enrollment-inducing events which carried enrollments and public investment in higher education to all-time highs in the mid-1970's. What of the remainder of the century?

## WILL THE EDUCATION BOOM CONTINUE?

The remainder of the century appears to harbinger factors which will end the higher education boom and cause, perhaps, absolute declines in enrollment. Nationally, the "baby bust" is predicted to reduce the number of 18-21 year-olds from its current post-war peak of almost 17 million to a low in the 1990's of less than 13 million.[11] Michigan's experience will mirror this trend, and

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[9]Stephan P. Dresch, "Demography, Technology, and Higher Education: Toward a Formal Model of Education Adaption" Journal of Political Economy, Vol. 83, No. 3, (June, 1975).

[10]Many of these studies are summarized in J. M. Campbell, Jr. and T. P. Curtis, "Graduate Education and Private Rates of Return: A Review of Theory and Empiricism" Economic Inquiry, Vol. 13, No. 1 (March, 1975).

[11]U. S. Bureau of the Census, Current Population Reports, Series P-25, No. 704, (July, 1977) "Projections of the Population of the United States: 1977to 2050."

relative economic conditions could result in a steeper decline if net out-migration should continue at present levels.

The newly-legislated cessation of GI bill benefits by 1989 will dramatically reduce and then eliminate a substantial pool of subsidized enrollees, especially at the two-year college level.[12] Of course, the lack of a military draft has already eliminated the derived-demand for higher education for young males, which fell back to pre-war levels after 1971.[13]

It is quite unlikely that the remainder of the century will produce a period of sustained economic growth and low inflation as was experienced in the 1960's. Per capita real income in Michigan which grew by 4.0 percent per year on average from 1960-69 and by 1.3 percent from 1969-1977, is projected by this study to grow even slower on average through the remainder of the century. This slower growth pattern, if realized, will most likely inhibit the process of educational widening and constrain the ability of government to maintain the real value of its subsidies to higher education. Continued unexpectedly high rates of inflation and the spector of tax revolt merely increase the uncertainty concerning the level and real value of government's direct and indirect support of higher education and, thus, the enrollment-inducing effects that have historically emanated from that source. The ability of colleges to cut costs in the face of relative or absolute declines in public support and/or enrollment is severely hampered by the high proportion of fixed labor costs at many institutions and an inability to "sell-off" idle

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[12]According to the Veterans Administration, the surge in veteran enrollment occurred in 1974-75 when the interwar veteran's delimiting date was passed. Nationally, six out of ten undergraduate veterans attended junior college in 1976, as compared to only three out of ten overall.

[13]See Table 4 and surrounding text for detailed information on age-sex specific participation rates.

plant and equipment if excess capacity should occur. Consequently, the explicit price of higher education will likely be under constant upward pressure relative to the general level of prices.

In addition, changing labor market conditions will likely cause changes in behavior which will alter the extent of higher education participation by certain age-sex cohorts. On the positive side, the now apparent change in tastes on the part of women from home to market work is predicted to cause continued increases in female labor force participation and, thus, the potential for growing participation in higher education. Second, mid-life career switching and career upgrading may attract larger numbers of non-traditional students than has historically been the case.[14]

On the negative side of probable changes in labor market conditions is the now apparent reversal in excess demand for college-educated labor. The highly educated baby-boom labor market entrant of the 1970's finds himself at the end of the long queue of similarly-educated persons, facing competition from a relatively large number of cohort companions as well. This competition for beginning jobs and advancement may have driven the person to higher education in the first place, but the consequence of this trend has, in aggregate, reduced the rate of return to higher education. Moreover, the demographics of cohort-size and consequent labor surpluses seemed to have made today's student more labor-market-oriented than his predecessor. He tends to exhibit less traditional attendance patterns and is more apt to switch curricula or institutions or even to drop out, according to changing

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[14]See Peter A. Morrison, The Demographic Context of Education Policy Planning, Report P-5592, Santa Monica: The Rand Corporation, 1976, and Nina Boren, et. al., "Second Career: An Integrated Learning Experience in Career Change for Older Persons," Industrial Gerontology, Vol. 3, No. 2 (Spring, 1976), for relevant material.

economic conditions.[15]

The smaller cohorts of the 1980's and 1990's will quite probably be similar in outlook. Not the least of causes for this orientation will be the relatively more attractive labor market opportunities portended by reduced competition within birth cohorts associated with the baby bust. These opportunities will be reinforced by the fact that labor markets are just now concluding the prolonged task of absorbing the baby-boom--the largest numbers of new entrants ever experienced. This suggests more vigorous bidding for the smaller cohorts of new entrants to follow, a large-scale repetition of the experience of the small birth cohorts of the 1930's and early 1940's.

In summary, some of the major causes of the higher education boom of the post-war period to date will be eliminated or reversed during the remainder of the century. Other contributing factors are subject to a great deal of uncertainty and, on balance, do not seem to provide any great promise for continued high growth in the demand for higher education. In order to quantify and project the impact of likely future economic-demographic experience on the demand for higher education in Michigan, it is necessary to develop a methodological approach to the problem, to gather data and quantify the model thus developed and then to simulate that model through the end of the century. To begin that process, the next section will review briefly the several possible methodologies available.

## ALTERNATIVE METHODOLOGIES

Economics has been heavily utilized in analyses of higher education. Such studies fall in four broad categories, each of which will be briefly

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[15]Daniel Yankelovich, The New Morality - A Profile of American Youth in the 1970's, New York: McGraw-Hill, 1974.

covered below, in sequence. The first to be discussed are rate of return studies.[16] These view higher education as an investment and seek to estimate a rate of return as discounted benefits and costs change. Although useful in identifying the opportunity costs of college attendance and obtaining an actual rate of return, these are of little use in policy-making beyond concluding that if the rate of return declines, attendance may be lower, to the extent such declines are perceived. The actual rate of return in such studies is also sensitive to the definition of and the monetary value attached to the consumption benefits of attendance. For example, it is as difficult to decide whether or not the acquired ability to interact in a diverse socio-economic environment is consumption or investment as it is to identify the market value of that acquisition. Furthermore, rate of return studies make the standard economic assumption of constant tastes, implying that all changes are due to income and price effects alone.

The second type of economic study devoted to education concentrates on education as human capital.[17] The human capital approach has yielded rich results on a variety of questions, ranging from the contribution of human capital to economic growth to the inter-generational transmission of ability. Like rate-of-return studies, the human capital approach is of limited use to enrollment forecasting because it concentrates on a variety of effects after higher education has been acquired.

The third and most extensive type of study is the choice-theoretic

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[16]See the Campbell and Curtis citation in footnote ten and Richard S. Eckhous, et. al., "An Appraisal of the Calculation of Rates of Return to Higher Education" in M. S. Gordan (ed.), Higher Education and the Labor Market, New York: McGraw-Hill, 1974.

[17]See W. Lee Hanson (ed.), Education, Income, and Human Capital, New York: Columbia University Press for National Bureau of Economic Research, 1970.

or conditional logit approach.[18] This approach essentially examines the array of choices facing a potential student, attaches a "utility" or benefit to each choice, and then determines the probability of attendance based on the costs of each choice and student characteristics. While computationally expensive, the choice-theoretic approach allows one to examine a large number of factors effecting enrollment decisions and to account for the complex interactions among factors in determining a student's probability of attendance. The major drawbacks of this approach are its high cost and its timeliness. Extensive survey data are needed to estimate such models. Once gathered, the responses may be valid only for the year in question. Finally, probability statements are not easily transformed into operational models which are useful to legislators, boards of trustees and the like.

The fourth type of economic study is the demand model,[19] which, in general, views higher education as a commodity, the demand for which is influenced by changes in relative prices, real income, tastes, and the opportunity costs of substitutes and compliments. Demand studies to date are certainly useful in demonstrating that it is instructive to treat higher education as a commodity, applying the tools of traditional economic theory. They are often too aggregated to be of use to those planners who must operate in a state-specific or institution-specific context, however. Moreover, those studies extant do not generally account for the interdependence among economic, demographic, and institutional variables.

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[18]These studies and others are surveyed in David J. Wernschrott, Demand For Higher Education In the United States: A Critical Review of the Empirical Literature, Report R-2195-LE, Santa Monica: The Rand Corporation, 1977.

[19]See G. A. Jackson and G. B. Weathersby, "Individual Demand for Higher Education," Journal of Higher Education, Vol. XLVI, No. 16 (Nov./Dec., 1975).

The subject study is a demand model which is Michigan-specific and presents a methodology which is readily adaptable to other state systems. It combines a highly disaggregated and interactive model of state economic and population dynamics with a disaggregated model of the demand for higher education -- by age, sex, and major type of institution. The subject study uses a time-series approach, employing data gathered for the 1960 to 1977 period. With this approach, changes in tastes over time can be captured and the impact of external events such as the Vietnam War can be calibrated. Furthermore, since the study disaggregates demand by age and sex, the changing patterns of enrollment among traditional and non-traditional cohorts can be examined and projected. Finally, the methodology is more comprehensible to policy-makers and planners, who are often not economists. The model can be periodically updated at relatively low cost, and above all is flexible -- admitting a wide variety of alternative projection scenarios, not just those of the author.

## AN OVERVIEW OF THE STUDY

In order to project the demand for higher education in Michigan by age and sex, using a time-series approach, it is necessary to first be able to forecast the population of the state on the same basis. Consequently, the researcher must be prepared to predict the impact of future births, deaths, and migration patterns on a highly disaggregated population. In demographic studies, it is quite usual to simply choose alternative birthrates and mortality rates and apply them iteratively to a base-year population. Migration is often treated in the same manner, but such an approach is insensitive to the pivotal fact that migration is related, in turn, to the economic and social climate of the state relative to the remainder of the nation. Therefore, it is desirable to be able to predict state economic-

demographic conditions simultaneously, which requires a sophisticated economic model of the state. The time path of variables such as unemployment rates, labor force, real income and migration can have potential important and immediate influence on the demand for higher education in a state-specific context, as demonstrated below.

The starting point for this study, therefore, is the comprehensive economic-demographic model of Michigan discussed in the next section. That model not only yields projections of important economic variables needed to erect the education model to follow, but provides the necessary annual population matrix,[20] disaggregated by age, race, and sex, which allows similarly differentiated treatment of the demand for higher education. Demographic disaggregation is critical to achieving projections which are at least somewhat sensitive to the dramatically different factors effecting the attendance patterns of different age and sex cohorts.

Once the researcher has the means to predict an annual population matrix as well as to estimate what it has been in the past (it is only measured at each decennial census), the study can proceed to the prediction of college attendance. The initial step is to choose an appropriate measure of the demand for education, which will become the dependent variable in the demand functions to be estimated. As will be pointed out below, the choice of such a variable is dictated in part by the extent and quality of the data available. This study will employ the participation rate, which is the proportion of a given age-sex cohort of potential enrollees who choose to "participate" (enroll) in formal, post-secondary education. Measured here in terms of headcount, the higher education participation rate describes the

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[20] A matrix is a two-dimensional array consisting of rows and columns. In this case, the population matrix has 86 rows representing ages 0 to 85 and over (85+), by single year of age, and has four columns representing the four major race-sex categories (white male, white female, non-white male, non-white female).

extent of demand at any point in time for the particular age-sex cohort in question.

The education model, the nature of which is discussed in the sections that follow the economic model, seeks to explain the past and present behavior of age and sex-specific participation rates, using, in part, variables sourced from the economic model. Enrollment projections, therefore, require the simultaneous projection of both the economic and education models from the base year (1977) to the terminal year (2000) of the projections. The final step is to multiply the projected participation rate for each age-sex cohort by the projected number of persons in each cohort, yielding a projection of enrollment. These enrollment projections are then summed to get aggregate state enrollment and are then disaggregated by major type of institution -- public four-year, public two-year, and private.

The modeling process begins, then, with the economic-demographic model of Michigan.

## THE ECONOMIC MODEL

The state economic model developed here has its antecedents in work by Mattila [31, 32, 33] and Moor [37] and most directly in a paper by Moor and Conger[21] which was the pilot for this study. This section summarizes the theory, data, and structure of the model and focuses on the economic-demographic projections. The formal variable definitions and the structural equations for both the economic and education models are contained in Appendix A. Appendix B presents some additional methodological detail.

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[21] D. J. Conger and J. R. Moor, Jr., "The Demand for Higher Education in Michigan: An Economic-Demographic Synthesis," a paper presented to the 52nd Annual Conference of the Western Economic Association, June 21, 1977. That paper contains a large amount of methodological detail and a well-developed version of the economic-demographic model. The education model, however, was primitive and preliminary to the work presented here.

The purpose of the simultaneous-equation, econometric forecasting model of Michigan's economy developed for this study is to simulate annual changes in highly disaggregated variables measuring economic activity and population for the data period 1960 to 1977, and then to forecast those variables annually to the year 2000 using varying sets of assumptions concerning the model's exogenous variables.[22] Demographers and economists alike have long recognized the simultaneous relationship between population and economic activity, especially at the regional level. Employment and income trends in local-service[23] industries, which generally comprise well over one-half of private sector employment and income in mature regional economies like Michigan, is determined in significant part by the growth rate of population and of the labor force in particular. In turn, the rate of growth in population, including the labor force, is critically related to changes in regional economic conditions, which play a central role in determining gross and net migration patterns -- the most volatile component of population change in the short-run.

The central task of the modeling process developed here is to capture these simultaneous relationships in order to develop more realistic and sensitive forecasts for the demand for higher education in a regional context. Two of the major drawbacks to precedent enrollment studies have been

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[22]An "exogenous" variable is one whose value at any point in time is determined outside the model in question and thus does not depend on the structure and inter-relationships within the model. On the other hand, an "endogenous" variable is one whose value at any given point in time is determined by and within the model structure.

[23]"Local-service" is used here to classify industries in a regional economy which produce primarily for the indigenous or "local" population, as opposed to producing primarily for export, (i.e., the "export" industries). Local-service industries include but are not limited to "service" industries, which produce intangible benefits rather than goods.

the acceptance of externally-generated, purely trend-demographic extrapolations of population and very limited interaction with simultaneously-determined economic variables. Trend-demographic studies employ assumptions about migration which are generally highly aggregated and based on a simple adaptation of intercensal net migration. They do not recognize or only pay lip-service to the two-way links among regional economic activity, migration, and the labor force.

Regional modeling often leads immediately to a "cart-before-the-horse" dilemma, that is, the existence of and access to region-specific data dictates the model structure rather than the converse. In this case, although the data base took over two years to gather, the availability of a reasonably long time-series of employment and wage and salary data by industry for Michigan and the lack of any semblance of regional income accounts other than the Department of Commerce's personal income estimates strongly suggested disaggregating the Michigan economy by industry. The economic dominance of the motor vehicle industry and its primary suppliers made the choice of industrial disaggregation a particularly easy one in the case of Michigan.

The economic data base consists primarily of wage and salary employment by industry, regional income by industry of origin, and the U. S. value of shipments for Michigan's export industries.[24] All industry data is at the two-digit or three-digit (SIC) level. Agricultural employment, self-employment (including domestics), and mining employment, which represent but seven percent of Michigan's total employment in 1977, are projected exogenously as a slightly declining proportion of wage and salary employment, reflecting the steady but more precipitous decline in their relative numbers through the data period. Income and value of shipments are measured in real 1972

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[24]The primary sources for this data are the Michigan Employment Security Commission and the U. S. Department of Commerce.

dollars, deflated largely by congruently-defined wholesale price indices by industry. Another important variable is a ratio used to capture changes in relative fuel prices over time, consisting of the wholesale price index for fuel products (including coal, electric power, gas fuels, and refined petroleum products) divided by an index of all prices -- the GNP deflator.[25] Some details on the definitions and estimation of data are contained in Appendices A and B.

The demographic data base consists of annual matrices (86 x 4) of the age-, sex-, and race-specific resident population of Michigan at mid-year (July 1), annual estimates of civilian labor force, fertility and mortality statistics, and annual estimates of net migration flows for whites and non-whites. Much of this data was estimated using a complex simulation routine iteratively from 1960 to 1977, based on primary data gathered from the U. S. Bureau of Census, U. S. Department of Labor, MESC, and the Michigan Department of Public Health. For each year of the simulation, the population matrix was also adjusted from a resident to a civilian, non-institutional basis for use in the labor force subroutine and the education model. The methodology employed in this simulation routine and its performance are discussed in greater detail in Appendix B.

It is the availability of annual estimates of highly disaggregated components of population change, as provided by the simulation, which in part differentiates this research from precedent enrollment studies. In turn, this detailed data allows the author to attempt to capture the simultaneous relationship between economic and demographic variables and to make estimates of demographically-disaggregated participation rates for higher education.

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[25]This ratio was calculated such that its base year is 1973, the initial year of the so-called "energy problem" (i.e., 1973=100). Its value in 1977 is 169, reflecting the dramatically greater rise in energy prices relative to other prices experienced from 1973 to 1977.

The structural form of the economic model is based in part on the export-base logic, which emphasizes the identification of export industries in a region and their economic relationship with the local-service industries. The external demand for the region's exports is seen as a prime-mover for the rate of regional economic growth. This approach is dictated, in the most practical sense, by the data constraint noted above -- there are simply no input-output studies nor any detailed set of regional economic accounts available for Michigan. The cost and time involved in gathering such data are prohibitive. In theoretical support of the export-base logic, the Michigan economy is perhaps the archetypical example of a regional economy dominated by a single industry -- the automobile industry. While Michigan represents an extreme, many other states have industry mixes which are dominated by one or a few large industries.

In any case, export industries sell the predominant portion of their output beyond the regional boundaries and thus are highly sensitive to fluctuations in external demand. Export industries often have significant backward linkages with other industries included in the export sector. Consequently, not only are they direct exporters of their own product, but they also sell a significant amount of their output to other export industries as input to further production processes.[26] Moreover, externally-sourced

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[26]The choice of industries which comprise the export sector of the model was based on analysis of employment and income-based location quotients, input-output coefficients from U. S. Department of Commerce, The Input-Output Structure of the U. S. Economy: 1967 and 1972, and data from various Censuses and Surveys of Manufacturers and Transportation. Those Michigan industries which are significant net exporters include motor vehicles, primary metals, fabricated metals, machinery, rubber, chemicals, and furniture. Of these, all but furniture have significant input-output relationships with the motor vehicle industry as well as among each other. The remaining industries are classified in the local-service sector, although by no means does their activity (especially the other manufacturing industries) preclude the export of some output.

growth in demand for export products generates growth in demand for locally-produced goods, as external demand translates into local income and spending and thus into local-service employment, in the familiar multiplier process.

An export-base model need not ignore the very significant impetus for regional growth that is generated internally, however. Local-service industries satisfy each other's significant demands for locally-produced goods, especially in a mature region like Michigan, as well as responding to the demands of a changing resident population. The rate of growth of the regional labor force, migration patterns, and the rate of growth of new household formation are all inter-dependent and simultaneously related to income and employment in the local-service sector.

The structural equations reproduced in Appendix A, Table A-2, are designed to capture the complex and inter-linked economic-demographic relationships summarized above. Variable abbreviations and definitions (Table A-1) precede the structural equations. The equations can be roughly divided into three categories -- income (YMV, etc.), employment (EMV, etc.), and demographic. The income variables measure regional income produced by each industry and are an output proxy. Consequently, the industry-specific income equations (1 through 20) are designed to calibrate the previously described economic interrelationships among industries. The export equations (1 through 8) include exogenous U. S. value of shipments variables (SHxxx) which measure the time path of external demand for Michigan's exports. The local-service and government income equations (9 through 20) include the regional labor force (FORCE) as a variable. It serves as a proxy for demand due to demographic change, approximating the number of earners and thus the number of local-spenders who are the decision-makers in regional households.

The relative fuel price variable (RFUEL) appears extensively in the export equations as well as in the equations of other manufacturing and construction industries. These industries tend to employ high proportions of capital relative to labor and tend to be energy-intensive. If fuel prices rise faster than other prices, a larger portion of the dollar value of demand for the products of energy-intensive industries is lost to the region, since Michigan is a significant net importer of energy. The dramatic rise in relative energy prices since 1973 and the probable continuation of this phenomenon through the end of the century requires inclusion of such an exogenous variable.

Table A-2 also details the industry-specific employment equations (21 through 40) which capture the relationship between regional employment and industry output (income). The demographic equations (41 through 49) calculate migration, population, labor force, and the regional unemployment rate. A large number of the highly disaggregated (by age, race, sex) calculations are accomplished by several subroutines which are derived from the 1960-1977 population simulation and are described in more detail below and in Appendix B. Of particular importance, however, are the white and non-white net migration equations (41 and 42), which close the simultaneous relationship between regional income, employment, and demographic conditions within the model. In those equations, the relative unemployment rate (RUNR) variable captures the extent to which Michigan's labor market conditions are better or worse than the national average -- a factor which tends to either pull people toward or away from Michigan. The value of RUNR depends jointly on the exogenously-determined national unemployment rate and the endogenously-determined regional unemployment rate. The latter, in turn, reflects the difference between the regional labor force and aggregate

employment. Since labor force depends, in part, on migration patterns and employment depends on the economic relationships among regional industries, the labor force, and external demand for exports, the simultaniety that exists in the real world is approximated in the model.[27]

The remaining equations in the demographic sector represent the internal computation of critical demographic variables -- the resident population, the civilian labor force, and the regional unemployment rate. Again, much of the age-, race-, and sex-specific disaggregation is accomplished in a subroutine similar to the 1960-77 population simulation previously mentioned and covered in more detail in Appendix B. That subroutine includes (1) the use of Michigan-specific birthrates and mortality rates to compute the annual change in resident population due to natural increase alone (NATINC), (2) the estimation of annual age-, race-, and sex-specific gross migration flows based on endogenously-determined net-migration, yielding a new resident population matrix adjusted for births, deaths, and migration, (3) the annual estimation of a civilian, non-institutional population matrix; and (4) the annual computation of the civilian labor force using national labor force participation rates adjusted for Michigan/U. S. differentials determined from Census data.

The structural coefficients reported in Table A-2 were estimated

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[27]The migration equations also include several additional endogenous variables which further capture critical economic-demographic linkages. The lagged change in labor force variable (LDLF) measures the extent of increases in labor supply, which in and of itself tends to "push" people from the region. Lagged per capita income (LPCY) represents an attractive force in the non-white equation and the lagged non-white proportion of the population (LNWP) represents the negative "crowding" effect associated with ghettoization and relatively higher rates of non-white unemployment. RIOT and STONC are exogenous variables, representing the impact of the 1967-68 Detroit riots and the "beaten path" effect of the well-documented south-to-north black migration of the 1950's and 1960's. They are not operative in the projection period.

using two-state-least-squares, except in those equations already in reduced-form. The estimation used seventeen or eighteen observations depending on the presence or absence of lagged regressors or instruments. Durbin-Watson statistics (not reported) indicated no significant autocorrelation in most equations. A Hildrith-Lu scanning technique, assuming a first-order auto-regressive scheme, was used in an attempted "fix" for those regressors with significant autocorrelation. In general, the highly volatile export sector tracked less satisfactorily than the local-service sector. Standard errors in the income equations range from four to seven percent for export industries, from two to five percent for local-service industries. Standard errors in the employment equations range from two to five percent for export, and one to five percent for local-service. The average standard error was 4.4 percent for income equations and 3.4 percent for employment equations through the data period.

The next section summarizes the projections derived from the Michigan economic model.

## ECONOMIC-DEMOGRAPHIC PROJECTIONS

In order to project the economic model's endogenous income, employment, and demographic variables from 1977 to 2000, it is necessary to convert the model's structural coefficients to reduced-form, modify the population simulation routine to utilize birthrate and mortality rate projections rather than actual data, and to specify alternative sets of projection assumptions for the model's exogenous variables. Before presenting these alternative assumptions and the projection values which result from them, it is imperative to define the general nature of these forecasts. The projection results summarized below, from either the economic or the education model, are

forecasts of the long-term trend[28] for each variable in question and do not purport to predict short-run cyclical swings in the Michigan economy or in higher education enrollment. Consequently, even if the assumptions contained in any particular projection scenario were to come true, one would expect the observed future values of the endogenous variables to fluctuate randomly about the projection path reported below. Moreover, long-run secular forecasts become less reliable the further one moves from the base year (1977), because of the increasing likelihood that the economic-demographic structure of the region will undergo change over time. In this regard, however, significant changes in industrial mix, inter-industry relationships and population dynamics tend to occur slowly, especially in industrially-mature regions like Michigan. The strength of the methodology employed here is that each passing year provides another data point which will capture the subtle changes in economic structures which occur over time. Additionally, the model is designed to accept a wide range of assumptions regarding the model's exogenous variables and thus offers flexibility to the planner or policy-maker.

Table 1 presents historical values and the author's choices of alternative projection assumptions for the economic model's exogenous variables. Except for labor force participation rates and mortality rates,[29] each

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[28]The forecasts are not to be confused with trend projections, i.e., some method which merely extends or extrapolates the trend of the 1960's and 1970's. Such methods, common to many demographic studies, do not require a well-specified underlying theory or a causal model, but rather forecast a given variable based on its own past performance and, perhaps, some casual assumptions about conditions which will impact that variable in the future.

[29]Civilian labor force participation rates by age and sex were projected based on forecasts found in U. S. Department of Labor, Monthly Labor Review--N. N. Fullerton, Jr. and P. O. Haim, "New Labor Force Projections to 1990," December, 1976, pp. 3-13, and R. W. Bendnerzik and D. P. Klein, "Labor Force Trends: A Synthesis and Analysis," October, 1977, pp. 3-15. Mortality rates were derived from life tables published by the Michigan Department of Public Health and adjusted through the projection period by change factors used by the U. S. Department of Commerce, Current Population Reports, Series P-25, No. 704. "Projections of the Population of the United States: 1977 to 2050." (July, 1977).

exogenous variable is assigned three values, characterized and labeled as "high," "medium," or "low". In the author's opinion, these alternative values describe a range of projections which are most likely to contain the future time path for Michigan's economy. The exogenous variables are (1) the aggregate U. S. rate of economic growth (real GNP) and associated aggregate unemployment rate, (2) U. S. value of shipments for Michigan's export industries, (3) relative fuel price changes, and (4) Michigan's fertility rates by age of mother.

The medium values for the national economic variables are derived from Commerce and Labor Department sources.[30] The high and low values represent a range about the medium values based on those data sources, past experience and the author's judgement. Post-1985 growth rates are the same or slightly lower than pre-1985 growth rates, reflecting an expected slowdown in the formation of new households and continued smaller productivity gains, coupled with increasing relative fuel prices. The medium assumptions are 3.5 percent average annual rate of real growth to 1985 and 3.0 percent from 1986 to 2000, a trend unemployment rate of 5.5 percent, and a rise in relative fuel prices averaging one percent per year to 1985 and two percent per year thereafter.[31] The medium birthrate assumption holds non-white fertility at its 1977 level

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[30]In particular, the author consulted U. S. Department of Commerce, Industrial Outlook - 1978 and Area Economic Projections 1990, (Bureau of Economic Analysis), 1974; U. S. Department of Labor, The Structure of the U. S. Economy to 1985, Bulletin 1831, 1975, and several articles in the Monthly Labor Review--C. T. Bowman and T. H. Morlan, "Revised Projections of the U. S. Economy to 1980 and 1985," March, 1976, pp. 9-21; T. J. Mooney and J. H. Tschetter, "Revised Industry Projections to 1985," November, 1976, pp. 3-22, and R. E. Kutscher, et. al., "The Productivity Slowdown and Outlook to 1985," May, 1977, pp. 3-8; and the 1978 Economic Report of the President.

[31]This would cause the relative fuel price index, which rose from 100 to 169 (69 percent in four years) during the 1973-77 experience to rise to 183 by 1985 and to 246 by the year 2000. (46 percent in 23 years; see Table 1).

TABLE 1

HISTORICAL DATA AND PROJECTION ASSUMPTIONS FOR EXOGENOUS VARIABLES
ECONOMIC MODEL

| ACTUAL | Compound Average Annual Growth Rate (a) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | U. S. Value of Shipments (1972 $) | | | | | | Relative |
| | Real GNP (1972 $) | Motor Vehicles | Fabricated Metals | Primary Metals | Chemicals | Rubber | Furniture | Fuel Price (b) |
| 1960-1977 | 1.036 | 1.051 | 1.029 | 1.020 | 1.050 | 1.063 | 1.043 | 1.025 |
| 1960-1969 | 1.043 | 1.057 | 1.058 | 1.043 | 1.071 | 1.078 | 1.060 | (1.020) |
| 1969-1977 | 1.032 | 1.045 | (1.006) | (1.002) | 1.026 | 1.046 | 1.024 | 1.079 |
| 1963-1969 | 1.045 | 1.051 | 1.065 | 1.046 | 1.069 | 1.077 | 1.064 | (1.024) |
| 1973-1977 | 1.020 | 1.024 | (1.037) | (1.014) | (1.033) | 1.006 | (1.023) | 1.139 |
| **Projection Assumptions** | | | | | | | | |
| 1977-1985 | | | | | | | | |
| High | 1.045 | 1.030 | 1.045 | 1.035 | 1.050 | 1.050 | 1.050 | 1.010 |
| Medium | 1.035 | 1.020 | 1.035 | 1.025 | 1.040 | 1.040 | 1.040 | 1.010 |
| Low | 1.025 | 1.015 | 1.025 | 1.015 | 1.030 | 1.030 | 1.030 | 1.010 |
| 1986-2000 | | | | | | | | |
| High | 1.040 | 1.020 | 1.035 | 1.025 | 1.040 | 1.040 | 1.040 | 1.030 |
| Medium | 1.030 | 1.015 | 1.030 | 1.020 | 1.030 | 1.030 | 1.030 | 1.020 |
| Low | 1.020 | 1.010 | 1.025 | 1.015 | 1.030 | 1.030 | 1.030 | 1.010 |
| **Comparison Projections (c)** | | | | | | | | |
| Commerce (77-83) | 1.035 | 1.020 | 1.040 | 1.025 | 1.050 | 1.051 | 1.041 | n/a |
| Labor (80-85) | 1.036 | 1.013 | 1.032 | 1.022 | 1.040 | 1.038 | 1.037 | n/a |

TABLE 1 (CONTINUED)
HISTORICAL DATA AND PROJECTION ASSUMPTIONS FOR EXOGENOUS VARIABLES
ECONOMIC MODEL

| | Completed Fertility Rate[d] | | Relative Fuel Price[b] | U.S. Unemployment | Civilian Labor Force Participation Rate[e] | | Memo: Endogenous Variables[f] | | |
|---|---|---|---|---|---|---|---|---|---|
| Actual | White | Non-white | (1973 = 100) | Rate | Male | Female | Michigan Unemployment Rate | Relative Unemployment Rate | Births (000) |
| 1960 | 3.79 | 4.09 | 110 | 5.5 | 83.3 | 37.7 | 6.7 | 122 | 195 |
| 1965 | 2.99 | 3.13 | 102 | 4.5 | 80.7 | 39.3 | 3.9 | 87 | 166 |
| 1970 | 2.47 | 3.12 | 92 | 6.7 | 79.7 | 43.3 | 4.9 | 137 | 172 |
| 1975 | 1.66 | 2.31 | 152 | 8.5 | 77.9 | 46.3 | 12.5 | 147 | 134 |
| 1977 | 1.67 | 2.25 | 169 | 7.0 | 77.7 | 48.4 | 8.2 | 117 | 138 |
| Average | | | | | | | | | |
| 1960-1977 | | | 112 | 5.4 | 80.0 | 42.1 | 6.6 | 119 | 162 |
| 1960-1969 | | | 102 | 4.8 | 81.2 | 40.0 | 5.4 | 112 | 174 |
| 1970-1977 | | | 121 | 6.3 | 78.6 | 45.4 | 8.1 | 127 | 145 |
| Projection Assumptions | | | | | | | | | |
| 1985 - High | 1.92* | 2.45 | 198 | 4.5 | | | 4.7 | 104 | 168 |
| - Medium | 1.92* | 2.25 | 183 | 5.5 | 78.3 | 51.1 | 6.3 | 114 | 166 |
| - Low | 1.67 | 2.20 | 169 | 6.5 | | | 7.8 | 120 | 147 |
| 2000 - High | 2.50 | 2.90 | 308 | 4.5 | | | 4.6 | 102 | 197 |
| - Medium | 2.10 | 2.25 | 246 | 5.5 | 76.8 | 55.1 | 7.0 | 128 | 163 |
| - Low | 1.67 | 2.10 | 196 | 6.5 | | | 9.5 | 146 | 132 |

TABLE 1
FOOTNOTES

(a)U. S. Department of Commerce data for two-digit SIC industry categories, deflated by equivalent wholesale price index adjusted to a 1972 base.

(b)Ratio of the wholesale price index for fuels, related products and power, (includes coal, electricity, gas fuels and refined petroleum products), to the GNP deflator, adjusted to a 1967 base, such that 1967=100 and, coincidently, 1973=100.

(c)U. S. Department of Commerce, Industrial Outlook, 1978 -- average of four-digit industry estimates reported, weighted by 1977 value shipments.

U. S. Department of Labor, "Revised Industry Projections to 1985," Monthly Labor Review, Nov. 1976 -- Average of 1980-85 growth rate projection for major industry sub-groups weighted by 1977 value of shipments.

(d)Historical rates are weighted averages of age-, race-, and sex-specific rates based on Michigan Department of Public Health data and 1960-77 population simulation. The projection assumptions converge to the values indicated (or remain constant as the case may be) except for those designated by an asterisk (*), which converge to 2.10 in 1990.

(e)Civilian labor force as a percent of the civilian noninstitutional population, age 16 and over. Projection values are averages of age and sex-specific rate projections, weighted by the medium growth population projection.

(f)The projection values of these variables are determined within the model, not by assumption. Births are based on the medium growth population projection, with varying birthrate assumptions.

(a 2.25 completed fertility rate) while allowing white rates to converge upward to the replacement rate (2.10) by 1990. The combination of these medium assumptions concerning national economic variables and Michigan birthrates is hereafter referred to as the "benchmark" projection assumptions and provide a comparison base for other projections, which allow one or more of the projection assumptions to vary.

Table 2 presents projection values for key economic and demographic variables at five-year intervals from 1980 to 2000 -- employment, resident population, regional income, per capita income, births, employment/population ratio, labor force, relative unemployment rate, and net migration. The first three columns compare the different projection values associated with the high, medium, and low national growth assumptions, holding relative fuel prices and birthrates constant at their medium values. Column two is the so-called benchmark projection. The next four columns hold the medium national economic growth assumptions constant, but allow the birthrate and relative fuel price assumptions to change. It can be seen that different birthrates cause significant demographic change but have relatively small effects on the economic variables, since the aggregate economic impact of higher or lower birthrates is delayed for fifteen to twenty years after birth. Higher or lower rates of increase in relative fuel prices have important impacts on all variables, but not as large as higher or lower rates of economic growth. In the last column of Table 2, when the low economic growth assumption is combined with low births and high relative fuel prices, zero population growth (ZPG) occurs by 1993, with Michigan's population peaking at about 9.7 million, as compared to 9.1 million today.

In summary, Michigan's population in the year 2000 is projected to range

TABLE 2
MICHIGAN ECONOMIC PROJECTIONS THROUGH 2000

| Total Employment (000) | Alternative Economic Growth Assumptions[a] | | | Medium Economic Growth[a] | | | | ZPG Assumptions[b] |
|---|---|---|---|---|---|---|---|---|
| | High | Medium* | Low | High Births | Low Births | High Fuel | Low Fuel | |
| 1977 | 3400 | 3400 | 3400 | 3400 | 3400 | 3400 | 3400 | 3400 |
| 1980 | 3656 | 3630 | 3604 | 3630 | 3630 | 3630 | 3630 | 3604 |
| 1985 | 4000 | 3902 | 3810 | 3902 | 3902 | 3902 | 3902 | 3810 |
| 1990 | 4296 | 4117 | 3965 | 4117 | 4116 | 4147 | 4085 | 3934 |
| 1995 | 4573 | 4289 | 4061 | 4289 | 4286 | 4375 | 4195 | 3970 |
| 2000 | 4889 | 4475 | 4156 | 4471 | 4466 | 4639 | 4290 | 3965 |
| Change | 1489 | 1075 | 756 | 1071 | 1066 | 1239 | 890 | 565 |
| CAGR[c] | 1.016 | 1.012 | 1.009 | 1.012 | 1.012 | 1.014 | 1.010 | 1.007 |
| **Population (000)** | | | | | | | | |
| 1977 | 9129 | 9129 | 9129 | 9129 | 9129 | 9129 | 9129 | 9129 |
| 1980 | 9284 | 9281 | 9277 | 9282 | 9268 | 9281 | 9281 | 9264 |
| 1985 | 9654 | 9600 | 9553 | 9608 | 9520 | 9600 | 9600 | 9472 |
| 1990 | 10230 | 10026 | 9879 | 10004 | 9820 | 10043 | 10006 | 9657 |
| 1995 | 10799 | 10390 | 10099 | 10463 | 10005 | 10501 | 10233 | 9651 |
| 2000 | 11318 | 10659 | 10190 | 10854 | 10203 | 10920 | 10368 | 9473 |
| Change | 2189 | 1530 | 1061 | 1725 | 1074 | 1791 | 1239 | 344 |
| CAGR[c] | 1.009 | 1.007 | 1.005 | 1.008 | 1.005 | 1.008 | 1.006 | 1.002 |
| **Total Income[d] (Billions of 1972 $)** | | | | | | | | |
| 1977 | $49.8 | $49.8 | $49.8 | $49.8 | $49.8 | $49.8 | $49.8 | $49.8 |
| 1980 | 55.5 | 54.7 | 54.0 | 54.7 | 54.7 | 54.7 | 54.7 | 54.0 |
| 1985 | 62.5 | 60.0 | 57.6 | 60.0 | 60.0 | 60.0 | 60.0 | 57.6 |
| 1990 | 68.3 | 64.0 | 60.4 | 64.0 | 64.0 | 64.6 | 63.4 | 59.8 |
| 1995 | 73.9 | 67.5 | 62.3 | 67.5 | 67.5 | 69.0 | 65.8 | 60.6 |
| 2000 | 80.4 | 71.3 | 64.2 | 71.2 | 71.1 | 74.2 | 68.0 | 60.8 |
| Change | $30.6 | $21.5 | $14.4 | $21.4 | $21.3 | $24.4 | $18.2 | $11.0 |
| CAGR[c] | 1.021 | 1.016 | 1.011 | 1.016 | 1.016 | 1.017 | 1.014 | 1.009 |

TABLE 2
MICHIGAN ECONOMIC PROJECTIONS THROUGH 2000 (Continued)

| | Alternative Economic Growth Assumptions[a] | | | Medium Economic Growth[a] | | | | |
|---|---|---|---|---|---|---|---|---|
| Labor Force (000) | High | Medium* | Low | High Births | Low Births | High Fuel | Low Fuel | ZPG Assumptions[b] |
| 1977 | 4096 | 4096 | 4096 | 4096 | 4096 | 4096 | 4096 | 4096 |
| 1980 | 4298 | 4296 | 4294 | 4296 | 4296 | 4296 | 4296 | 4294 |
| 1985 | 4565 | 4540 | 4517 | 4540 | 4540 | 4540 | 4540 | 4516 |
| 1990 | 4865 | 4767 | 4696 | 4765 | 4763 | 4776 | 4757 | 4684 |
| 1995 | 5130 | 4929 | 4786 | 4926 | 4920 | 4984 | 4871 | 4724 |
| 2000 | 5443 | 5115 | 4882 | 5112 | 5080 | 5245 | 4917 | 4710 |
| Change | 1347 | 1019 | 786 | 1016 | 984 | 1149 | 821 | 614 |
| CAGR[c] | 1.012 | 1.010 | 1.008 | 1.010 | 1.009 | 1.011 | 1.008 | 1.006 |
| Relative Unemployment Rate[e] | | | | | | | | |
| 1977 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 |
| 1980 | 121 | 122 | 124 | 122 | 122 | 122 | 122 | 124 |
| 1985 | 110 | 117 | 122 | 117 | 117 | 117 | 117 | 122 |
| 1990 | 97 | 115 | 127 | 115 | 114 | 111 | 119 | 130 |
| 1995 | 97 | 119 | 135 | 119 | 117 | 107 | 132 | 145 |
| 2000 | 100 | 125 | 142 | 125 | 120 | 108 | 144 | 157 |
| Net Migration[f] (000) | | | | | | | | |
| 1977 | - 33 | - 33 | - 33 | - 33 | - 33 | - 33 | - 33 | - 33 |
| 1980 | - 23 | - 23 | - 23 | - 23 | - 23 | - 23 | - 23 | - 23 |
| 1985 | - 1 | - 9 | - 16 | - 9 | - 9 | 9 | - 9 | - 18 |
| 1990 | 27 | 2 | - 14 | 4 | 5 | 8 | 1 | - 17 |
| 1995 | 28 | - 3 | - 25 | - 4 | - 1 | 15 | - 19 | - 44 |
| 2000 | 24 | - 11 | - 36 | - 15 | - 5 | 14 | - 41 | - 65 |

TABLE 2
MICHIGAN ECONOMIC PROJECTIONS THROUGH 2000 (Continued)

| | Alternative Economic Growth Assumptions[a] | | | Medium Economic Growth[a] | | | | |
|---|---|---|---|---|---|---|---|---|
| Per Capita Income (1972 $) | High | Medium* | Low | High Births | Low Births | High Fuel | Low Fuel | ZPG Assumptions[b] |
| 1977 | $5452 | $5452 | $5452 | $5452 | $5452 | $5452 | $5452 | $5452 |
| 1980 | 5979 | 5898 | 5818 | 5897 | 5906 | 5898 | 5898 | 5826 |
| 1985 | 6478 | 6248 | 6029 | 6243 | 6302 | 6248 | 6248 | 6081 |
| 1990 | 6673 | 6385 | 6110 | 6371 | 6520 | 6432 | 6337 | 6190 |
| 1995 | 6844 | 6496 | 6164 | 6446 | 6720 | 6576 | 6408 | 6281 |
| 2000 | 7101 | 6688 | 6296 | 6562 | 6973 | 6792 | 6561 | 6419 |
| Change | 1676 | 1263 | 871 | 1137 | 1548 | 1367 | 1136 | 994 |
| CAGR[c] | 1.012 | 1.009 | 1.006 | 1.008 | 1.011 | 1.010 | 1.008 | 1.007 |
| **Births (000)** | | | | | | | | |
| 1977 | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 |
| 1980 | 149 | 149 | 149 | 150 | 142 | 149 | 149 | 143 |
| 1985 | 167 | 166 | 165 | 168 | 147 | 166 | 166 | 146 |
| 1990 | 180 | 177 | 174 | 180 | 145 | 176 | 176 | 142 |
| 1995 | 177 | 169 | 163 | 187 | 138 | 171 | 167 | 132 |
| 2000 | 176 | 163 | 154 | 197 | 132 | 169 | 158 | 121 |
| **Employment/ Population Ratio** | | | | | | | | |
| 1977 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 |
| 1980 | .39 | .39 | .39 | .39 | .39 | .39 | .39 | .39 |
| 1985 | .41 | .41 | .40 | .41 | .41 | .41 | .41 | .40 |
| 1990 | .42 | .41 | .40 | .41 | .42 | .41 | .41 | .41 |
| 1995 | .42 | .41 | .40 | .41 | .43 | .42 | .41 | .41 |
| 2000 | .43 | .42 | .41 | .41 | .44 | .42 | .41 | .42 |

TABLE 2

FOOTNOTES

(a) Unless otherwise noted (as in columns four through seven), medium birth and relative fuel price assumptions are used in conjunction with the economic growth assumption indicated.

(b) The ZPG assumptions are low economic growth, low births, and high relative fuel prices, which together produce a population which peaks in 1993 at 9,681,000 and falls thereafter.

(c) Compound average annual growth rate.

(d) Real, aggregate income generated by industry of origin; not the exact equivilent of personal income which is on a "where received" rather than a "where produced" basis, and includes the net effect of government transfers among other adjustments.

(e) The ratio of Michigan / U.S. aggregate unemployment rates, multiplied by 100.

(f) Five year average of net migration, up to and including the year in question.

*This is the so-called benchmark projection (based on medium economic growth, medium births, medium fuel assumptions).

31

from as high as 11.3 million under the quite favorable (and unlikely) high economic growth assumptions, to about 10.6 million in the benchmark projection, and about 10.2 million under less favorable economic or fertility assumptions. The major reason for population variation is the cumulative effect of net migration patterns, which change from negative to positive under the high economic growth assumptions, decline in size but remain negative or near zero under medium assumptions, and continue at recent levels under low assumptions.[32] Per capita real income grows more slowly than in the past under any projection scenario. The employment/population ratio is quite stable from projection to projection and compares almost identically to those assumed by the Department of Commerce [46] in its most recent regional projections.[33] The model captures and reproduces the equilibrating nature of migration flows as they theoretically relate to imbalances between labor supply and demand in a region. Labor migrates in or out so as to maintain the relative unemployment rate within its historical range -- about 100 to 150. As shown in Table 1, unemployment in Michigan averaged nearly one-third higher than the national rate during the 1970's to date reaching a high of 47 percent in 1975. Michigan's unemployment rate was below the national rate only during the halcyon days of post-war auto boom --1963 to 1966.

Before turning to the education model, it is instructive to look at the projected numbers of non-institutionalized civilians who will be in

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[32]See Table B-2 for annual estimates of white and non-white net migration as estimated by the 1960-77 population simulation. From 1971 to 1977, Michigan experienced an average decline of over 30,000 persons per year due to net out-migration.

[33]A rapidly rising or falling ratio would be indicative of structural instability within the model, producing a growing gap between labor supply and demand that could not be closed by migration flows over the long-run.

those age cohorts which demand higher education. Table 3 presents historical estimates and projections of the pool of potential enrollees in higher education, non-institutionalized civilians from 18 to 49 years of age. Several important facts stand out: (1) the number of 18-21 year-olds peaked in the mid-1970's and will fall steadily and significantly until the late 1990's under all projection scenarios, (2) the number of 22-24 year-olds peaks about 1980 and declines thereafter, and (3) the only age cohorts which grow in numbers after 1985 are those over 30 years of age. In this environment, to maintain constant enrollment, educational participation rates would have to rise significantly. Barring increased participation by traditional students, non-traditional participation would have to rise to unimaginable heights, given that the baby-boom is already the most highly-educated cohort ever to pass through our population.

Table 3 also points out the impact of varying economic growth assumptions on the pool of potential enrollees, when birthrates and relative fuel prices are held constant at their medium values. Up through 1985 there are relatively small differences in the pool among the high, medium, and low projections. By 1990, however, there is roughly a 100,000 person gap between each projection, which expands from 250,000 (low vs. medium) to 350,000 (high vs. medium) by the year 2000. The growing gap reflects among other things the cumulative impact of different net migration patterns on the 18-49 year-old age group. Assuming a constant 12.5 percent aggregate higher education participation rate for 18-49 year-olds,[34] the headcount

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[34]As will be seen below, 12.5 percent is the 1977 aggregate participation rate -- the highest achieved in Michigan's history and as high or higher than any rate projected in this study. The aggregate participation rate is a weighted average of the individual age-sex specific rates.

TABLE 3
MICHIGAN'S POOL OF POTENTIAL ENROLLEES IN HIGHER EDUCATION
(Thousands of Noninstitutionalized Civilians)

| | Traditional Cohorts | | | Non-Traditional Cohorts | | | | Total |
|---|---|---|---|---|---|---|---|---|
| Actual[a] | 18-21 | 22-24 | Subtotal | 25-29 | 30-34 | 35-49 | Subtotal | 18-49 |
| 1960 | 366 | 262 | 628 | 472 | 535 | 1520 | 2527 | 3155 |
| 1965 | 478 | 311 | 789 | 473 | 469 | 1556 | 2498 | 3287 |
| 1970 | 605 | 405 | 1010 | 589 | 484 | 1529 | 2602 | 3612 |
| 1975 | 694 | 471 | 1165 | 724 | 585 | 1465 | 2774 | 3939 |
| 1977 | 700 | 486 | 1186 | 758 | 630 | 1458 | 2846 | 4032 |
| Projected[b] | | | | | | | | |
| High-1980 | 681 | 502 | 1183 | 809 | 711 | 1513 | 3033 | 4216 |
| 1985 | 623 | 486 | 1109 | 858 | 799 | 1753 | 3410 | 4519 |
| 1990 | 616 | 452 | 1068 | 844 | 862 | 2070 | 3776 | 4844 |
| 1995 | 566 | 450 | 1016 | 812 | 852 | 2340 | 4004 | 5020 |
| 2000 | 635 | 440 | 1075 | 786 | 824 | 2475 | 4085 | 5160 |
| Medium-1980 | 681 | 502 | 1183 | 809 | 710 | 1513 | 3032 | 4215 |
| 1985 | 618 | 482 | 1100 | 851 | 794 | 1745 | 3390 | 4490 |
| 1990 | 599 | 437 | 1036 | 818 | 842 | 2038 | 3698 | 4734 |
| 1995 | 536 | 423 | 959 | 765 | 810 | 2268 | 3843 | 4802 |
| 2000 | 587 | 401 | 988 | 717 | 758 | 2347 | 3822 | 4810 |
| Low-1980 | 680 | 502 | 1182 | 808 | 710 | 1512 | 3030 | 4212 |
| 1985 | 614 | 478 | 1092 | 844 | 790 | 1738 | 3372 | 4464 |
| 1990 | 588 | 426 | 1014 | 800 | 827 | 2014 | 3641 | 4655 |
| 1995 | 513 | 405 | 918 | 732 | 780 | 2217 | 3729 | 4647 |
| 2000 | 553 | 374 | 927 | 668 | 711 | 2257 | 3636 | 4563 |

[a] Derived from 1960-1977 population simulation

[b] Only economic growth assumptions vary, birthrates and relative fuel price assumptions are held constant at their medium projection values

enrollment impact of alternative economic growth assumptions is a difference of about 12,000 students in 1985, rising to a differential of from 30,000 to 45,000 students by the year 2000.

When one recognizes the fact that the mix among traditional and non-traditional students is changing dramatically over the projection period, it seems highly likely that the aggregate participation rate, which is a weighted average, will fall during the projection period in absence of significant increases in traditional participation rates. Decline will, in fact, be the case when we examine the projections of the education model, which is discussed next.

## THE EDUCATION MODEL

The purpose of the education model is to project the demand for higher education in Michigan through the remainder of the century in a time-series context. In order to do so, it is necessary to "explain" or model the time path of higher education demand in the past, rather than merely go through some exercise in trend extrapolation. This approach requires a theoretical model which identifies those variables which influence the demand for higher education by age and sex, and the empirical estimation of those causal relationships. The nature of the demand model erected in this study and thus the character of the projections which derive from that model are determined, in part, by the quantity and quality of data available to the task. As in the case of the economic model, the limited data base available is a constraint on the modeling effort -- more severe in the case of modeling regional education demand than for the economic model.

The only consistent and sufficiently detailed data collected for the 1960-1977 period for Michigan is fall headcount enrollment by institution.

Other measures of market conditions[35] in higher education, such as full-time equivalent students (FTE) and fiscal year equated students (FYES) are available only for shorter periods, are not consistently defined over those data periods, and do not have a companion data source of quality collected on a national basis. It was the existence of demographically-detailed national enrollment data collected and published by the Department of Commerce[36] which confirmed the use of fall headcount enrollment as the data base for a Michigan-specific demand variable. Unfortunately, no educational statistic, even headcount, for Michigan is disaggregated by age or sex of student on a time-series basis. This fact necessitated the derivation of Michigan-specific age-sex participation rates for higher education by combining national and regional data.

The task of generating an acceptable dependent variable measuring the Michigan demand for higher education was accomplished in several steps. First, national participation rates by sex were computed from U. S. data for the following age cohorts--16-17, 18-19, 20-21, 22-24, 25-29, 30-34, and 35 and over. These participation rates are formed by dividing the

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[35]Not necessarily equilibrium conditions, since supply-side constraints (e.g., space, information) and non-price rationing (e.g., quotas, admission standards) may not allow enrollment statistics to be interpreted as equilibrium values.

[36]The most recent of this series of reports based on the Current Population Survey is U. S. Department of Commerce, Current Population Reports, Series P-20, No. 319 (February, 1978) "School Enrollment--Social and Economic Characteristics of Students: October, 1976." Similar data by age, race, sex, type of institution, student socio-economic status, and other characteristics is available on an annual (October) basis, under various titles, in the P-20 series. Enrollment figures include persons attending a two-year or four-year college, university, or professional school (e.g., medical or law) but exclude persons attending trade school, business college, and enrollment which does not advance the student toward a recognized college degree.

number of October enrollees in higher education by the civilian non-institutional population for each age and sex cohort in question. Second, because of their small numbers, 16-17 year-old enrollments, were combined with 18-19 year-olds and divided by the 18-19 year-old population only. Thus, for this study, enrollments and the pool of potentially enrolling population are congruently defined as being 18 to 49 years of age, but participation rates include the very small number of enrollees under 18 years of age. Third, because the demand functions estimated for the 30-34 and 35 and over age cohorts were virtually identical, and because these students are both clearly non-traditional, those cohorts were combined in the final form of the study.

Last, these national participation rates were adjusted by using the ratio of Michigan and U. S. participation rates by age and sex derived from the 1960 and 1970 Censuses of Population, the only demographically-detailed source of enrollment and population data for Michigan which has a congruently-defined national counterpart. The application of these adjustment factors yielded estimates of Michigan-specific participation rates by age and sex from 1960 to 1977.

Table 4 details these estimates of Michigan-specific higher education participation rates by age and sex from 1960 to 1977. Several characteristics of Michigan's demand for education are notable. The bulge in the participation of young males during the 1965-71 Vietnam period is obvious. Participation of 18-21 year-old males has returned to pre-Vietnam levels since 1971. Female participation has trended steadily upward for all age groups -- traditional and non-traditional alike. Likewise, non-traditional male participation has risen over the period, most dramatically during the post-Vietnam years. These participation rates, then, are the dependent variables

TABLE 4
HIGHER EDUCATION PARTICIPATION RATES BY AGE AND SEX[a]
MICHIGAN -- 1960 - 1977
(October Headcount as Percent of Civilian Non-Institutional Population)

| Year | 18-19[b] | | 20-21 | | 22-24 | | 25-29 | | 30-49 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 1960 | 39.5 | 26.2 | 29.7 | 12.1 | 15.9 | 3.1 | 8.7 | 1.9 | 1.6 | 1.0 |
| 1961 | 40.2 | 26.8 | 31.7 | 13.8 | 14.5 | 3.5 | 7.4 | 2.1 | 1.4 | 1.0 |
| 1962 | 45.2 | 28.7 | 33.1 | 14.4 | 18.9 | 3.7 | 9.0 | 1.7 | 1.6 | 1.0 |
| 1963 | 40.7 | 27.7 | 35.7 | 16.7 | 20.6 | 4.2 | 8.0 | 2.4 | 1.5 | 1.0 |
| 1964 | 44.6 | 29.5 | 36.8 | 17.8 | 17.1 | 4.4 | 8.5 | 2.6 | 1.6 | 1.1 |
| 1965 | 48.3 | 33.4 | 40.6 | 18.3 | 22.2 | 6.2 | 9.7 | 3.2 | 1.7 | 1.2 |
| 1966 | 48.2 | 33.5 | 45.0 | 19.3 | 22.7 | 6.6 | 10.2 | 3.7 | 1.6 | 1.1 |
| 1967 | 46.9 | 34.2 | 47.9 | 21.9 | 21.7 | 6.9 | 10.1 | 3.4 | 1.9 | 1.2 |
| 1968 | 50.1 | 35.8 | 49.1 | 19.9 | 21.1 | 7.9 | 11.2 | 3.3 | 1.8 | 1.3 |
| 1969 | 50.3 | 36.3 | 50.4 | 23.2 | 24.0 | 9.0 | 11.9 | 4.2 | 2.0 | 1.5 |
| 1970 | 46.4 | 36.6 | 46.0 | 21.6 | 22.3 | 9.2 | 11.5 | 4.2 | 1.9 | 1.4 |
| 1971 | 47.2 | 36.9 | 42.6 | 24.9 | 24.6 | 8.3 | 12.6 | 4.5 | 2.6 | 1.9 |
| 1972 | 43.7 | 36.6 | 40.5 | 24.7 | 22.4 | 9.1 | 13.0 | 5.8 | 3.1 | 2.3 |
| 1973 | 40.3 | 33.9 | 37.9 | 24.3 | 20.2 | 10.1 | 12.6 | 6.0 | 3.1 | 2.6 |
| 1974 | 39.1 | 35.5 | 38.1 | 24.4 | 20.6 | 11.2 | 13.4 | 7.5 | 3.9 | 3.4 |
| 1975 | 41.9 | 38.9 | 38.3 | 25.7 | 21.3 | 12.5 | 13.8 | 7.9 | 4.6 | 3.9 |
| 1976 | 39.7 | 39.3 | 36.1 | 28.5 | 22.0 | 14.2 | 13.1 | 8.0 | 4.0 | 4.2 |
| 1977[c] | 40.4 | 40.3 | 35.0 | 29.1 | 21.1 | 14.9 | 13.5 | 8.9 | 3.4 | 4.3 |
| Average | | | | | | | | | | |
| 1960-77 | 44.0 | 33.9 | 39.7 | 21.1 | 20.7 | 8.1 | 11.0 | 4.5 | 2.4 | 2.0 |
| 1960-64 | 42.0 | 27.8 | 33.4 | 15.0 | 17.4 | 3.8 | 8.3 | 2.1 | 1.5 | 1.0 |
| 1965-71 | 48.2 | 35.2 | 45.9 | 21.3 | 22.7 | 7.7 | 11.0 | 3.8 | 1.9 | 1.4 |
| 1972-77 | 40.9 | 37.4 | 37.7 | 26.1 | 21.2 | 12.0 | 13.2 | 7.4 | 3.7 | 3.5 |

## TABLE 4
## FOOTNOTES

(a) Based on national participation rates as estimated by the U.S. Bureau of Census, Current Population Reports, Series P-20, adjusted for differences between Michigan and U.S. enrollment patterns by age and sex according to the 1960 and 1970 censuses, and for the July-October Michigan population differential.

(b) Participation rate computed using 16-19 year-old enrollees as numerator.

(c) Projection based on education model, using actual 1977 values for exogenous variables.

used in the educational model, measuring the demand for higher education in Michigan by age and sex.

In order to validate their usefulness, it remains to see if they accurately reproduce the actual enrollments experienced in Michigan from 1960 to 1977. Only then will a model derived from using the participation rates be acceptable for purposes of projecting the future. To validate the rates, it was necessary to multiply each Michigan participation rate by the appropriate estimate of civilian, non-institutional population derived from the 1960 to 1977 population simulation yielding enrollment estimates by age and sex. These estimates were then aggregated to yield an "estimate" of total fall enrollment for Michigan for the years 1960 to 1977, which could then be compared to actual enrollment.

Table 5 presents historical enrollment patterns for Michigan for 1960 to 1977 by major type of institution (private colleges, public four-year colleges and universities, and public two-year colleges). For the sake of brevity, public four-year institutions will sometimes be called "baccalaureate" institutions in this study and public two-year schools will sometimes be called "junior colleges." In addition, the right-hand portion of Table 5 compares Michigan's actual aggregate enrollment to that "estimated" by using the dependent variable derived according to the procedure described above. The estimates came within 10,000 enrollees of the actual number in twelve of the seventeen years, and deviated by no more than 27,000, this during 1969 and 1970 at the height of Vietnam distortions. One-half of the deviations were one percent or less and only the 1969 and 1970 differences exceeded four percent of aggregate enrollment. The average deviation was 2.2 percent for aggregate enrollment and just over one percent for four-year public institutions, if 1969 and 1970 are excluded. Interestingly the

TABLE 5
HISTORICAL ENROLLMENT PATTERNS - MICHIGAN, 1960-1977
(October Headcount in Thousands)

| Year | Actual Enrollment/(Share)[a] | | | | | Simulated Enrollment[b] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Public | | | | Aggregate | +/- Actual | | |
| | Private | 2-Yr. | 4-Yr. | Total | Aggregate | (000) | (000) | Percent | Memo: 4-Yr. |
| 1960 | 36(21) | 27(16) | 108(63) | 135(79) | 171 | - | - | - | - |
| 1961 | 38(21) | 32(17) | 112(62) | 144(79) | 182 | 181 | - 1 | * | 112 |
| 1962 | 40(20) | 34(18) | 120(62) | 154(80) | 194 | 195 | 1 | * | 121 |
| 1963 | 41(19) | 38(19) | 129(62) | 167(81) | 208 | 205 | - 3 | -1% | 126 |
| 1964 | 44(19) | 46(20) | 143(61) | 189(81) | 233 | 230 | - 3 | -1 | 142 |
| 1965 | 48(18) | 58(22) | 162(60) | 220(82) | 268 | 256 | -12 | -4 | 158 |
| 1966 | 49(17) | 70(24) | 176(59) | 246(83) | 295 | 301 | 6 | 2 | 182 |
| 1967 | 50(16) | 80(25) | 188(59) | 268(84) | 318 | 315 | - 3 | -1 | 182 |
| 1968 | 51(15) | 96(28) | 198(57) | 294(85) | 345 | 335 | -10 | -3 | 193 |
| 1969 | 51(14) | 115(31) | 208(55) | 323(86) | 374 | 347 | -27 | -7 | 197 |
| 1970 | 52(13) | 126(32) | 218(55) | 344(87) | 396 | 369 | -27 | -6 | 203 |
| 1971 | 53(13) | 132(33) | 220(54) | 352(87) | 405 | 404 | - 1 | * | 220 |
| 1972 | 51(12) | 136(34) | 219(54) | 355(88) | 406 | 411 | 5 | 1 | 218 |
| 1973 | 51(12) | 153(36) | 222(52) | 375(88) | 426 | 436 | 10 | 2 | 225 |
| 1974 | 55(12) | 174(38) | 230(50) | 404(88) | 459 | 460 | 1 | * | 230 |
| 1975 | 61(12) | 197(40) | 241(48) | 438(88) | 499 | 489 | -10 | -2 | 240 |
| 1976 | 60(12) | 188(39) | 237(49) | 425(88) | 485 | 502 | 17 | 3 | 240 |
| 1977 | 60(12) | 187(39) | 237(49) | 424(88) | 484 | 505 | 21 | 4 | 242 |

(a) Source: Michigan Department of Education.
(b) Computed by simulating education participation rate model from 1961-1977 and using the age-sex specific rates to generate enrollments for each cohort by multiplying the corresponding element of the civilian non-institutional population. The enrollments were then aggregated and multiplied by the simulated private and baccalaureate shares.
* Less than 0.5 percent.

baccalaureate institutions absorb most of the 1969 and 1970 errors but almost none of the error in the other years -- a further indication that 1969 and 1970 were atypical years for Michigan. Over the data period, then, the participation rates estimated for Michigan do an acceptable job of reproducing Michigan's actual enrollment experience.

Several potential difficulties are inherent in this approach, however, and should be noted. First, the enrollment variable used does not distinguish between first-time and continuing enrollees or between full-time and part-time enrollees. Naitonal data derived from the Labor Department's Current Population Survey indicates that, in aggregate, first-year students have remained a relatively stable proportion of all students and of the total 18-34 year-old population. This data is not available by age group, however, and only goes back to 1967. The same data source shows that, except for the non-traditional age groups, full-time students as a proportion of total students have remained remarkably stable from 1960-1976, with small increases for young males occurring during the Vietnam period. Students over twenty-five have shown a tendency to increase full-time enrollments over the data period, although the proportion exhibits a relatively large degree of variability.

Second and more important to the interpretation of the projection results below, is the marked change in aggregate enrollment patterns for Michigan relative to the U. S. in the last two years of the data period, 1976 and 1977. Chart 1 depicts the time path of the aggregate higher education participation rate from 1960 to 1977.[37] This is the only participation rate which allows a direct comparison between actual Michigan

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[37]The aggregate participation rate is defined as total fall enrollment divided by the civilian non-institutional population, 18-49 years of age.

data and actual U. S. data. Michigan demonstrates a steadily upward trend in higher education participation, remarkably similar but consistently higher than the national participation rate. There are only two exceptions over the eighteen-year period, the 1969-1970 bulge in Michigan's experience noted above, and the dramatic decline of Michigan's participation to national levels in 1976 and below the national rate in 1977. Using age-and sex-specific national rates as the starting point for deriving Michigan participation rates by age and sex, then, results in the underprediction in 1969 and 1970, and the overprediction in 1976 and 1977 that appear in Table 5. Unfortunately, these latter two years are at the end of the data period. Consequently, the projections will reflect an upward bias, especially for two-year colleges, unless the decline in Michigan's participation relative to the nation in the last two years can be explained. Fortunately, it appears that most, if not all, of the apparent 1976-77 decline in Michigan's participation relative to national trends represents a change in the official state definition of enrollment[38] rather than a fundamental shift in demand. Consequently, projected enrollments merely reflect the previous (1960-1975) definition of headcount and do not appear to contain any upward bias due to underlying behavioral factors.

The next step in the modeling process is to find variables to explain the 1960 to 1977 time-path of the derived, Michigan-specific participation rates. This requires a theoretical model of educational demand, data to

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[38]Beginning in 1976 and as a matter of policy in 1977, the State of Michigan requires that "community service" or so-called "leisure time" enrollment be excluded from headcount reported by two-year schools. It would appear that a large portion if not all of the apparent participation decline is due to a change in the State's official definition of headcount.

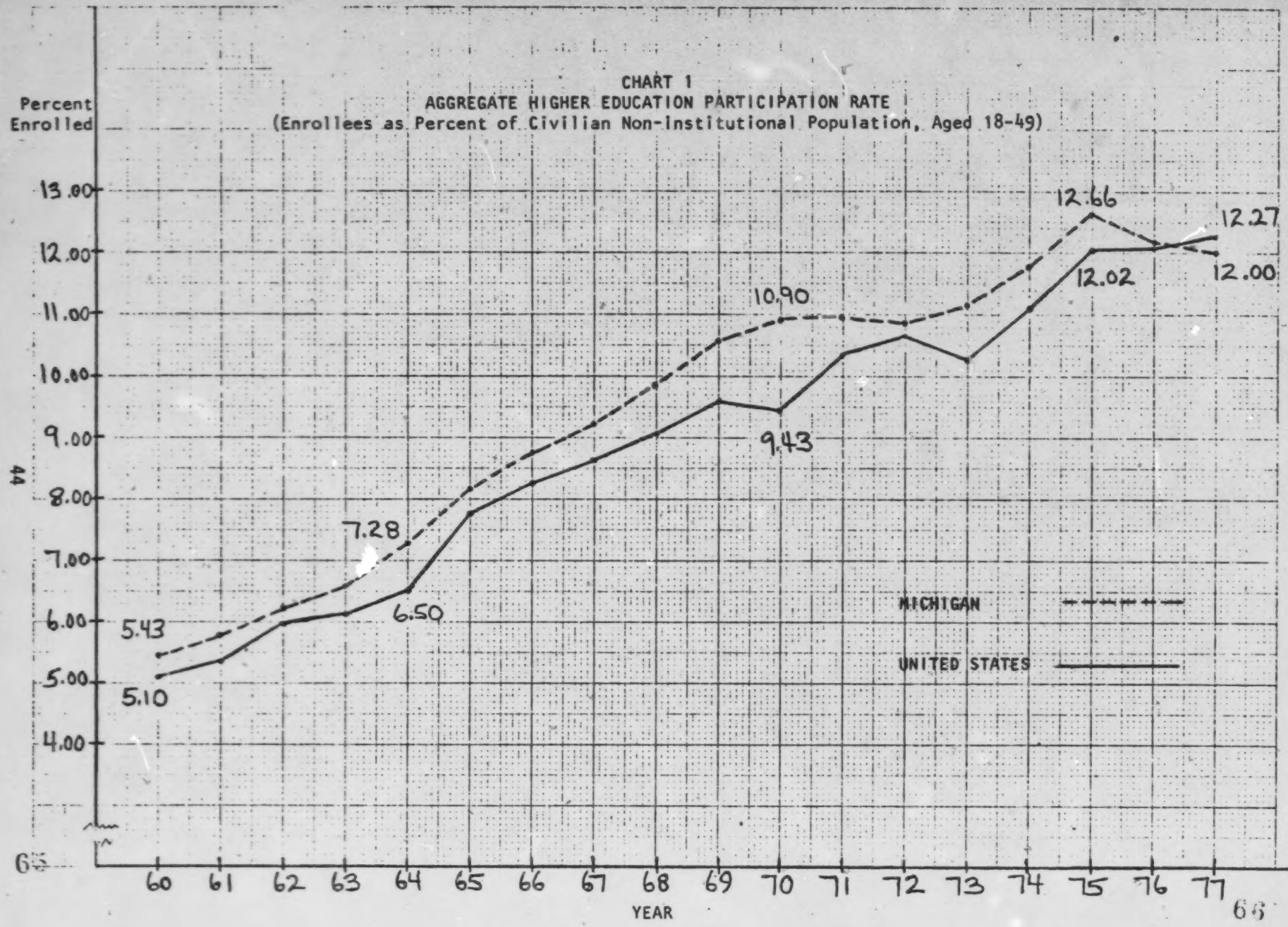
CHART 1
AGGREGATE HIGHER EDUCATION PARTICIPATION RATE
(Enrollees as Percent of Civilian Non-Institutional Population, Aged 18-49)
Percent Enrolled
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
12.66
12.27
12.00
12.02
10.90
9.43
7.28
6.50
5.43
5.10
MICHIGAN
UNITED STATES
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77
YEAR

measure the explanatory variables, and empirical estimation of the relationships among those variables and the participation rates. The theoretical framework for the model is the Becker approach to individual choice behavior,[39] which treats the allocation of time and goods over the life-cycle simultaneously, as inputs to so-called "household production functions." Households are thought to produce commodities by combining purchases of market goods and time. Among these commodities are work (labor force participation), recreation, health, children (fertility rates), and education -- both informal (on-the-job training, home study, etc.) and formal (higher education participation in particular). A detailed statement of this theoretical framework is presented in Appendix C.

To simplify the theoretical framework, the structural model and projections of demand classify the explanatory variables utilized in this study into five categories. The determinants of the demand for higher education over time are grouped as follows: (1) the price of education relative to other market commodities and among alternative institutions, where the price of education is the sum of direct, private costs -- tuition, room, and board; (2) real per capita income; (3) direct public subsidies to higher education such as grants, loans, and veteran's benefits; (4) the opportunity costs of substitutes and compliments to higher education, including contemporaneous labor market conditions, the "taste" for future labor force participation, and military service; (5) and variables such as relative educational attainment or relative cohort size for different age-sex groups in society which directly influence the actual or perceived productivity of various household alternatives. Most of the exogenous variables used in the educational model are listed by category and variable across the top of Table 6. The body of

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[39]See bibliography entries [3], [4], and [5] for primary sources.

TABLE 6
HISTORICAL DATA FOR EXOGENOUS VARIABLES[a]
EDUCATION MODEL

| Year | Relative Prices | | | Income and Direct Subsidies (Real 1972 $) | | |
|---|---|---|---|---|---|---|
| | Public, 4-Yr/ Other Goods (RPRICE) | Private/ Public, 4-Yr (PTOB) | Public 4-Yr/2-Yr (BTOJ) | Aggregate Per Capita Income (PCY) | Average Scholarship Award (AVGSD) | Veterans Benefits Mils (MVEED) |
| 1960 | 0.82 | 1.19 | 7.27 | $3455 | 0 | $ 10.9 |
| 1961 | 0.85 | 1.22 | 6.86 | 3308 | 0 | 6.8 |
| 1962 | 0.89 | 1.25 | 6.46 | 3627 | 0 | 4.0 |
| 1963 | 0.92 | 1.29 | 6.07 | 3878 | 0 | 2.5 |
| 1964 | 9.92 | 1.37 | 5.66 | 4098 | $406 | 1.6 |
| 1965 | 0.93 | 1.44 | 5.31 | 4510 | 371 | 1.0 |
| 1966 | 0.93 | 1.48 | 5.43 | 4659 | 374 | 0.8 |
| 1967 | 1.00 | 1.40 | 5.72 | 4529 | 397 | 9.2 |
| 1968 | 0.97 | 1.52 | 5.44 | 4861 | 390 | 13.5 |
| 1969 | 0.99 | 1.53 | 4.98 | 4935 | 396 | 19.3 |
| 1970 | 1.01 | 1.57 | 5.12 | 4422 | 389 | 32.2 |
| 1971 | 1.02 | 1.57 | 4.80 | 4696 | 395 | 50.4 |
| 1972 | 1.03 | 1.56 | 4.96 | 5041 | 403 | 57.0 |
| 1973 | 1.00 | 1.60 | 5.17 | 5366 | 456 | 72.7 |
| 1974 | 0.96 | 1.61 | 5.37 | 4620 | 439 | 77.6 |
| 1975 | 0.94 | 1.66 | 5.18 | 4464 | 417 | 104.8 |
| 1976 | 0.98 | 1.63 | 5.17 | 5069 | 440 | 115.3 |
| 1977 | 0.98* | 1.63* | 5.17* | 5452 | 439 | 77.0 |
| Averages | | | | | | |
| 1960-77 | 0.95 | 1.47 | 5.56 | $4499 | $317 | $ 36.5 |
| 1960-69 | 0.92 | 1.37 | 5.92 | 4186 | 233 | 7.0 |
| 1970-77 | 0.99 | 1.60 | 5.12 | 4891 | 422 | 73.4 |

TABLE 6
HISTORICAL DATA FOR EXOGENOUS VARIABLES (Continued)
EDUCATION MODEL

| Year | Productivity Effects | | Opportunity Costs of Compliments Substitutes | | | | |
|---|---|---|---|---|---|---|---|
| | Relative Male Cohort Size 15-24/25-34 (COHORT) | Female Educ. Attainment Gap, 25-34/35-54 (GAPF) | Female Labor Force Partic. Rate Age 35-44 (FLFR44) | Michigan Military Inductions 000 (INDUCT) | U.S. Unemployment Rates (b) All Workers Age 16+ (UNRT) | High School Graduates Age 25-34 Male (MHUR34) | High School Graduates Age 25-34 Female (FHUR34) |
| 1960 | 0.98 | 2.5 p.p. | 43.5% | 90 | n/a | n/a | n/a |
| 1961 | 1.06 | 2.7 | 43.8 | 60 | n/a | n/a | n/a |
| 1962 | 1.15 | 2.8 | 44.1 | 158 | 6.0 | 4.4 | 6.0 |
| 1963 | 1.21 | 3.2 | 44.9 | 74 | n/a | n/a | n/a |
| 1964 | 1.28 | 3.5 | 45.0 | 151 | 5.5 | 3.4 | 6.8 |
| 1965 | 1.35 | 3.8 | 46.1 | 103 | 4.7 | 2.8 | 5.9 |
| 1966 | 1.40 | 4.7 | 46.9 | 340 | 3.7 | 2.1 | 3.5 |
| 1967 | 1.41 | 5.6 | 48.1 | 299 | 3.6 | 2.3 | 3.8 |
| 1968 | 1.40 | 5.5 | 48.9 | 265 | 3.4 | 1.9 | 4.4 |
| 1969 | 1.40 | 6.1 | 49.9 | 207 | 3.1 | 1.5 | 4.2 |
| 1970 | 1.44 | 7.3 | 51.1 | 156 | 4.2 | 3.0 | 4.0 |
| 1971 | 1.48 | 8.4 | 51.6 | 27 | 5.8 | 4.4 | 6.6 |
| 1972 | 1.44 | 9.6 | 52.0 | 36 | 6.1 | 4.1 | 5.1 |
| 1973 | 1.39 | 10.7 | 53.3 | 0 | 5.2 | 3.5 | 5.6 |
| 1974 | 1.36 | 11.8 | 54.7 | 0 | 5.3 | 4.0 | 5.3 |
| 1975 | 1.34 | 12.2 | 55.8 | 0 | 9.2 | 9.0 | 10.0 |
| 1976 | 1.30 | 13.0 | 57.8 | 0 | 8.1 | 7.5 | 8.8 |
| 1977 | 1.26 | 15.8 | 59.6 | 0 | 7.9 | 7.1 | 8.3 |
| Averages | | | | | | | |
| 1960-77 | 1.31 | 7.2 p.p. | 49.8 | 109 | 5.5% | 4.1% | 5.9% |
| 1960-69 | 1.26 | 4.0 | 46.1 | 175 | 4.3 | 2.6 | 4.9 |
| 1970-77 | 1.38 | 11.1 | 54.5 | 27 | 6.5 | 5.3 | 6.7 |

(a) For detailed definitions, see Table A-1.

(b) Based on Department of Labor estimates for March of each year.

* Not available for 1977, assumed to be identical to 1976.

Table 6 details their historical values and some useful averages over the 1960-1977 data period.

The price of institution-specific higher education is determined by taking weighted averages of tuition, room, and board for Michigan's public and private institutions from 1960 to 1976, using enrollments as weights. The price of two-year college is based on tuition only. Those weighted averages are then paired to form price relatives between institutions and also paired with the "price" of all other goods, represented by the Michigan consumer price index. Real per capita income and the relative size of various 15-24 year-old population cohorts compared to 25-34 year-old cohorts are derived from the economic model. Contemporaneous labor market conditions are approximated with age-specific unemployment rates for high school graduates[40] while the changing tastes for future labor market entry is captured by older labor force participation rates (35-44 year-olds). Military service constraints are measured by Michigan-specific inductions into the armed services, while the service-related benefits are Michigan-specific veteran's educational expenditures, deflated by the state consumer price index. Likewise, other government subsidies are deflated and expressed in the form of average real dollars per student recipient. The average student loan, tuition grant, and scholarship were all utilized in the empirical estimation of the model. Finally, the educational attainment gap between 25-34 year-olds and 35-54 year-olds is measured by using national data.[41]

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[40]U.S. Department of Labor, Special Labor Force Report 193, March, 1977 and earlier annual reports.

[41]U.S. Department of Commerce, Current Population Report, "Educational Attainment in the United States: March 1977 and 1976," Series P-20, No. 314 and earlier reports.

To estimate the relationship between these explanatory variables and the age and sex-specific participation rates, it was necessary to make several assumptions. First, this study treats Michigan as a closed system of higher education, with relatively small gross flows of migrating students and insignificant net flows.[42] Consequently, Michigan's population alone was used as the basis for simulating and projecting enrollments. Second, since this study relies on a time-series approach using cohort data rather than the individual survey data typical of cross-section studies, this model implicitly assumes no major changes in the distribution of income or in other relevant family socio-economic characteristics that are not explicitly treated in the model. Third, the model does not distinguish clearly between the investment and consumption aspects of higher education, treating it as a single, lumpy commodity. Such distinctions, as noted above, are common to rate of return studies. Last, it is assumed that relative availability of information among prospective enrollees concerning higher education and its alternatives has not and will not undergo any dramatic changes. Such assumptions are usual for studies of this sort and are dictated by the lack of existing data at the level of detail necessary to treat these potential problems explicity.

The structural equations estimated for the higher education model are found in Table 7 and again in Appendix A, Table A-2, together with the formal definitions for each variable. There are ten participation rate equations,

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[42]According to Tuckman [45], Michigan experiences a college student voluntary outmigration rate of about 10 percent compared to a national average of 18 percent. Recent information suggests that inmigration is less than 10 percent of total enrollment. For most institutions, excepting the University of Michigan and Michigan State University, inmigration is probably small. Furthermore, the small proportion of private schools, residency requirements for public, two-year schools, and significant tuition subsidies and financial aid to state residents mitigate against significant interstate flows of students.

TABLE 7
STRUCTURAL EQUATIONS -- EDUCATION MODEL

| | | | | $R^2$ | Standard Error | Mean | S.E. as a % of Mean |
|---|---|---|---|---|---|---|---|
| (1) | RM19 | = | 29.74 + .0246299 INDUCT + 8.47270 COHORT<br>(6.26) (5.57) (2.29) | .777 | 1.99 | 44.24 | 4.5% |
| (2) | RM21 | = | -8.50 + .3227 LRM19 + .0214156 INDUCT + 23.7592 COHORT<br>(-1.08)* (1.35)* (3.55) (3.72) | .896 | 2.05 | 40.62 | 5.0% |
| (3) | RM24 | = | 1.29 + .0013787 PCY + .209753 MHUR24 + .2891 RM21<br>(0.40)** (1.48)* (1.62)* (3.11) | .743 | 1.53 | 20.72 | 7.4% |
| (4) | RM29 | = | 1.06 + .0200892 MVEED + 1.75 GIBILL + .00199711 PCY<br>(0.64)** (2.71) (2.45) (5.06) | .904 | 0.71 | 10.85 | 6.5% |
| (5) | RM49 | = | 0.11 + .0157984 MVEED + 0.88 GIBILL + .0002950 PCY<br>(0.25)** (7.03) (7.39) (3.31)<br>+ .0760137 MHUR34<br>(2.26) | .990 | 0.12 | 2.35 | 5.1% |
| (6) | RF19 | = | 4.44 + .52549 FLFR44 + .0102878 AVGSD<br>(0.77)** (1.04) (3.15) | .871 | 1.61 | 33.52 | 4.8% |
| (7) | RF21 | = | -18.43 + .3303 LRF19 + .5500 FLFR44 + .042205 AVGSD<br>(-5.29) (2.32) (4.66) (1.81) | .958 | 0.97 | 21.21 | 4.6% |
| (8) | RF24 | = | -22.96 + .685845 FLFR44 + .025336 AVGSD - 4.16720 RPRICE<br>(-6.87) (15.56) (1.92) (-1.71)* | .979 | 0.53 | 7.65 | 6.9% |
| (9) | RF29 | = | 4.91 + .000425 PCY - 6.76612 RPRICE + .58397 GAPF<br>(2.67) (1.37)* (-2.40) (16.67) | .976 | 0.36 | 4.27 | 8.4% |
| (10) | RF49 | = | 4.05 + .0001831 PCY - 5.8787 RPRICE + .295515 GAPF<br>(4.76) (1.47)* (-5.13) (16.40)<br>+ .105554 FHUR34<br>(3.94) | .987 | 0.14 | 1.84 | 7.6% |

TABLE 7 (Continued)

| | | | | | | $R^2$ | Standard Error | Mean | S.E. as a % of Mean |
|---|---|---|---|---|---|---|---|---|---|
| (11) | VSHARE | = | 54.37 | - 17.9345 PTOB | - 13.0150 RPRICE | .961 | .72 | 15.72 | 4.6% |
| | | | (17.88) | (-9.18) | (-2.60) | | | | |
| (12) | BACP | = | 65.76 | - 1.74242 BTOJ | - .0274628 MVEED | .992 | .82 | 67.66 | 1.2% |
| | | | (11.18) | (-1.92) | (-1.78) | | | | |

*Not significant at the 95.0% level of confidence, but significant at the 90.0% level.
**Not significant at the 90% level of confidence.

five for each sex, which are then subdivided into 18-19, 20-21, 22-24, 25-29, and 30-49 year-old age cohorts. Ordinary-least-squares was used to estimate each equation. Durbin-Watson statistics, which are not reported in Table 7, indicate, without exception, that no significant autocorrelation exists, suggesting strongly that the small unexplained errors, which range from four to eight percent, are due to random variation over time, probably associated with explanatory variables which have random impacts on participation but are not included in the model specification.

Relative price (RPRICE) and income (PCY) variables were used initially as regressors in each of the ten age- and sex-specific relationships. Male participation was, without exception, unrelated to relative price changes and only non-traditional male students (RM29, RM49) were sensitive to real income trends. Older females (RF24, RF29, RF34), however, appear to be much more responsive to price stimuli and also exhibit significant, although less dramatic income responses. Young female participants (RF19, RF21), like young males, exhibit income and price elasticities which are not significantly different from zero. In those cases when income or price coefficients are significantly different from zero, the demand response is inelastic and in the expected direction.[43]

Direct subsidies to higher education participation have the effect of changing the relationship between relative prices for education and other goods. Again, traditional male participation (RM19, RM21, RM24) showed no significant relationships to the availability of loan, scholarship, or tuition subsidies provided by the State. On the other hand, the average real scholarship award (AVGSD) and the average real student loan were both highly related

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[43]Participation and relative price increases are negatively related, as expected, while real income and participation exhibit the expected positive relationship. Other studies have concluded that higher education is highly price inelastic [14,28]. This inelasticity is undoubtedly due, in part, to the fact that the tuition, room and board often represent but a small portion of the market clearing price for the highly subsidized merit good -- higher education.

to participation in the traditional female cohorts, although only the former was used in the structural equations because of multicollinearity. These results suggest a commonly accepted conclusion -- that habit persistence by young males is stronger than among young females with respect to acquiring formal education, making males less responsive to changes in income or out-of-pocket costs. This is due largely, one would suspect, to the historically high level of labor force participation among men relative to women, reflecting their traditional roles in society. Veterans benefits (MVEED, GIBILL), on the other hand, are highly related to participation among non-traditional male students, reflecting the large number of post-Korean and post-Vietnam veterans who have populated our campuses, especially junior colleges, during the 1970's.

Growing educational participation among traditional female cohorts parallels the dramatic change in tastes among women for market rather than household work, as women secure formal credentials in anticipation of labor force entry. Their demand for higher education, then, is derived from the change in tastes for a complimentary good, labor market participation. Thus, it is no surprise that traditional female educational participation rates were highly and positively related to labor force participation rates for older females (FLFR44), which was used as a proxy for the changing tastes for market work on the part of women in all age cohorts. In all equations, moreover, unemployment rates by age cohort, specific to high school graduates and to college graduates, were used in an attempt to capture the impact of contemporary labor market conditions as an alternative or substitute for college-going. The unemployment rate for high school graduates (MHUR34, FHUR34) was significantly and positively related to participation for both males and females over thirty years of age. In all other cases but one (RM24),

the unemployment rate variables were either insignificant or entered with the wrong sign.[44]

It remained to find significant explanatory variables for young male and older female cohorts which were not purely price, income, or opportunity cost variables. It is commonly accepted that young males "escaped" from conscription during the Vietnam War in part by enrolling in college, and inductions of Michigan males (INDUCT) are, indeed, highly related to the bulge in traditional male participation from 1965 to 1971. The rather dramatic impact of the demographic twist associated with the baby boom also may have played a meaningful role in determining traditional male participation. Economics, in general, and rate of return studies, in particular, suggest that a larger number of intra-cohort competitors will lower the rate of return to higher education. However, as individuals, young males will see the attainment of more formal schooling as both a way to out-compete or at least keep up with their fellow cohort members and as a means to delay entry into a crowded segment of the labor market. During the late 1960's and early 1970's, the size of the 15-24 year-old cohort in Michigan peaked relative to the number of 25-34 year-olds, becoming nearly fifty percent higher due to the baby boom. Historically, those two cohorts have been roughly equal in size. During the remainder of the century, however, the 15-24 year-old cohort will actually become smaller than its older counterpart due to the baby bust of the last two decades. The relative size of these two cohorts (COHORT) was a significant explanatory variable for young male participation rates, although not for young females, who have not

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[44]It is expected that rising unemployment for high school graduates in the same age cohort would tend to increase participation (positive sign), ceteris paribus, and that rising unemployment among college graduates would mitigate against participation (negative sign).

experienced widespread intra-cohort competition in the labor market to date.

Next, in an attempt to explain non-traditional female student enrollment patterns, this study employed educational attainment gap variables (GAPF) to measure the differential between older and younger segments of the population. Assuming the usual direct relationship between formal education and market productivity, an increasing demand for labor force participation among all female cohorts should create a derived demand for higher education in the older, less well-educated cohorts. Thus, the educational attainment gap variable represents the perception of higher productivity by the older female participant who either intends to reenter the labor force, upgrade her occupation, or compete directly with younger females as a new entrant. While occupational upgrading is also present among males (the other two motives are not common), the corresponding male educational attainment gap variable was not significantly related to the non-traditional male participation rates. One suspects that older males, in aggregate, rely more on on-the-job experience for upgrading than on formal education, and that the participation rates for older males, which have traditionally been higher than the comparable female rates, have reflected ongoing career switching and occupational upgrading among males since well before the data period.

Last, the 20-21 year-old participation rate equations for both sexes contain the lagged participation rate for 18-19 year-olds, the purpose of which is to capture the carryover enrollment associated with the attendance patterns for the four-year, baccalaureate degree. This is necessary because the cohorts involved are only two years in length. Because of a shortage of degrees of freedom, however, other lagged relationships were not attempted except for the possible carryover into 22-24 year-old cohorts associated with educational deepening and lower course loads. This is significant only

in the case of males, who have evidenced to date much higher propensities for formal education beyond the age of twenty-two.

Two more equations appear in Table 7 designed to identify causes for the changing institutional mix of higher education enrollments in Michigan. The private share of Michigan's enrollments (VSHARE) and the baccalaureate or four-year proportion of Michigan's public enrollments (BACP) are estimated by equations (11) and (12). In each case, relative prices play the significant explanatory role, with the addition of veterans' benefits to the BACP equation capturing the inordinately high share of older males who gravitated toward two-year colleges during the recent surge of veteran participants.

As was pointed out above, this model was simulated through the 1960-1977 data period, using actual data (Table 6) for the exogenous (right-hand) variables in each equation, some of which are derived from the economic model. The simulated participation rates thus obtained were multiplied by the corresponding cohort population counts from the population simulation, to yield enrollment estimates. These enrollments were then aggregated to obtain the estimates shown in Table 5, which were discussed earlier. The structural relationships in the education model were then used to project enrollment to the year 2000. In order to project enrollment beyond 1977, however, it is first necessary to project the model's exogenous variables, which is the initial task described in the next section of this study.

## THE ENROLLMENT PROJECTIONS

Projection assumptions for the exogenous variables of the education model are presented in Table 8. For each variable not sourced from the

TABLE 8
PROJECTION ASSUMPTIONS FOR EXOGENOUS VARIABLES[a]
EDUCATION MODEL

| Relative Prices | Abbreviation : Remarks | 1977 Actual | Alternative Projection Assumptions, 1978-2000[b] Optimistic | Base | Pessimistic |
|---|---|---|---|---|---|
| Public, 4-Yr/ Other Goods | RPRICE : Will tuition room and board rise faster or slower than the general price level? | 0.98 | Decline to 0.85 by 2000 | Hold constant at 0.98 | Increase to 1.10 by 2000 |
| Private/ Public, 4-Yr | PTOB : Will public tuition, room and board rise or fall relative to private colleges? | 1.63 | Hold constant at 1.63 | Decline to 1.50 in 1985, hold constant thereafter | Decline to 1.50 in 1985, then to 1.33 by 2000 |
| Public, 4-Yr/ Public, 2 Yr | BTOJ : Will junior and community college tuition rise relative to baccalaureate? | 5.17 | Decline to 4.50 in 1985, then to 4.00 by 2000 | Decline to 4.50 in 1985, hold constant thereafter | Hold constant at 5.17 |
| Income and Direct Subsidies (Real 1972 $) | | | | | |
| Aggregate Per Capita Income | PCY : Depends on state economic and demographic conditions | $5452 | Determined in economic model, value depends on projection assumptions for economic growth, birth rates, and relative fuel prices. | | |
| Average Scholarship | AVGSD : Will the legislature maintain the real value of the state scholarship award? | $439 | Hold constant at 439 | Decline to 400 by 1985, hold constant thereafter | Decline to 220 by 2000 |
| Veterans Education Benefits in Michigan | MVEED : Current law terminates all benefits by 1988 (1989-2000=0) | $77M | Slower decline based on fixed pool of potential users | Decline based on post-Korean experience | Faster decline |

57

TABLE 8 (Continued)
PROJECTION ASSUMPTIONS FOR EXOGENOUS VARIABLES[a]
EDUCATION MODEL

| Productivity Effects | Abbreviation : Remarks | Actual | Alternative Projection Assumptions, 1978-2000[b] Optimistic | Base | Pessimistic |
|---|---|---|---|---|---|
| Relative Male Cohort Size 15-24/25-34 | COHORT : The baby boom/bust causes ratio to peak in 15.'1 and to fall through most of the rest of the century[c] | 1.26 | Do not allow to fall below 1.10[c] | Do not allow to fall below 1.10[c] | Allow to fall to projected level[c] |
| Gap in Female Educational Attainment 25-34/35-54 | GAPF: The highly-educated baby boom first reaches 35 years of age in 1982 and is completely over 35 by 1996. | 15.8p.p. | 1980: 17p.p.<br>1985: 16<br>1990: 13<br>1995: 10<br>2000: 8 | 16p.p.<br>14<br>11<br>8<br>6 | 14p.p.<br>12<br>7<br>5<br>5 |
| **Opportunity Costs** | | | | | |
| Female Labor Force Participation Rate, Age 35-44 | FLFR44 : Based on Department of Labor estimates | 54.5% | There are no alternative projections, see Table 1 for labor force participation rate projections | | |
| Military Inductions | INDUCT | 0 | 0 | 0 | 0 |
| Male/Female High School Unemployment Rates, 25-34 | MHUR34 / FHUR34 | 7.1%<br>8.3% | Value determined in economic model, based on three alternative interpretations of the recent relationship between high school graduate experience and the aggregate unemployment rate | | |

[a] See Table 6 for historical data and Table A-1 for detailed definitions of each variable.

[b] Alternatives are classified as optimistic, base or pessimistic according to their impact on public, 4-yr enrollments.

[c] Value determined in economic model, e.g., benchmark projection yeields 1985(0.95), 1990(0.90), 1995(0.91), 2000(1.03).

economic model, the alternative assumptions are classified into one of three categories -- optimistic, base, or pessimistic. These characterizations pertain to the likely impact of any given assumption alternative on public four-year enrollments, which comprised at least one-half of Michigan's higher education enrollment throughout the data period. For example, the first exogenous variable is RPRICE, the price relative between baccalaureate tuition, room, and board and all other goods. Its value was 0.98 in 1977, after reaching a high of 1.03 in 1972. A steady decline of that relative over the projection period to a value of 0.85 in the year 2000 is viewed to be optimistic. A decline in the relative means that the price of higher education is projected to rise a bit more slowly than the cost of living. Alternately, a rise in the price relative was considered to be pessimistic, while the steady-state, that is holding RPRICE constant, was judged to be a reasonable compromise or base assumption. It should be noted that any assumption may be made about these variables in the model methodology, not just the three chosen for the projections reported in this study.

While Table 8 details the alternative assumptions concerning each exogenous variable, several deserve additional comment. First, it is the author's best guess that two-year college costs will rise faster than baccalaureate costs during the remainder of the century due to more severe funding pressures among other causes. Therefore, only the pessimistic assumption forecasts a steady-state for that price relative (BTOJ). For the same reason, the study anticipates some decline in the real value of state subsidies to higher education (AVGSD), thus, only the optimistic assumption is a steady-state. The author strongly suspects that the enrollment-inducing intra-cohort competition created by the baby-boom is

asymmetrical, thus, higher education participation of young males should not fall off as the number of 15-24 year-olds shrinks to below the number of 25-34 year-olds in the years to come. For all but the pessimistic assumption, therefore, the relative cohort size variable (COHORT) is not allowed to fall below 1.10, well above its projected value for the 1980's and 1990's. Last, the evidence available supports a dramatic closing of the higher education attainment gap as the highly-educated baby boom reaches the older cohorts. By the year 1996, the entire baby boom will be over thirty-five. Consequently, unless we experience another surge in traditional student participation equal to or greater than that of the sixties and seventies, the gap must close. It seems highly improbable, therefore, that the non-traditional student of the future will be seeking higher education in the proportions currently experienced.

The enrollment projections which result from the combined economic and enrollment models are summarized in Table 9. The first four columns of that table hold medium economic projection assumptions constant but vary the educational assumptions. The table presents projection values for the aggregate participation rate, total enrollment in higher education, public four-year enrollment, and public two-year enrollment for 1977 and at five-year intervals from 1980 to 2000. The year and value at which each variable reaches a minimum is also presented, together with the maximum percentage decline from 1977 associated with that low point.

The impact of alternative sets of education projection assumptions, as summarized in Table 9, begins to make substantial differences in enrollment levels by 1985, and those differences tend to become more exaggerated in the 1990's. Without exception, minimums occur in the mid to late 1990's. It is instructive to see what occurs if age- and sex-specific participation

TABLE 9
MICHIGAN ENROLLMENT PROJECTIONS THROUGH 2000[a]
(October Headcount In Thousands)

| Aggregate Participation Rate | Medium Economic Growth Assumptions | | | | Base Education Assumptions | | | | Pessimistic Educ. Assump. |
|---|---|---|---|---|---|---|---|---|---|
| | Constant 1977 P/R[b] | Education Assumptions | | | ZPG[d] | Low Growth | Medium Growth[c] | High Growth | Low Growth |
| | | Optimistic | Base[c] | Pessimistic | | | | | |
| 1977 | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% |
| 1980 | 12.0 | 12.3 | 12.0 | 11.6 | 12.0 | 12.0 | 12.0 | 12.0 | 11.6 |
| 1985 | 11.1 | 11.5 | 11.0 | 10.3 | 11.0 | 10.9 | 11.0 | 11.0 | 10.3 |
| 1990 | 10.4 | 10.5 | 10.0 | 8.9 | 9.9 | 9.9 | 10.0 | 10.1 | 8.8 |
| 1995 | 9.7 | 9.6 | 9.0 | 8.0 | 8.9 | 8.9 | 9.0 | 9.2 | 7.9 |
| 2000 | 10.0 | 9.7 | 9.1 | 8.4 | 8.7 | 8.9 | 9.1 | 9.2 | 8.2 |
| **Total Enrollment** | | | | | | | | | |
| 1977 | 505 | 505 | 505 | 505 | 505 | 505 | 505 | 505 | 505 |
| 1980 | 508 | 519 | 506 | 490 | 506 | 505 | 506 | 507 | 490 |
| 1985 | 497 | 516 | 493 | 462 | 489 | 488 | 493 | 498 | 458 |
| 1990 | 491 | 499 | 473 | 421 | 462 | 462 | 473 | 488 | 411 |
| 1995 | 468 | 463 | 433 | 384 | 407 | 413 | 433 | 460 | 366 |
| 2000 | 479 | 469 | 435 | 403 | 383 | 406 | 435 | 477 | 375 |
| Low(Yr) | 468(95) | 460(97) | 428(97) | 384(95) | 383(00) | 403(98) | 428(97) | 459(96) | 365(96) |
| Percent Change | - 7% | - 9% | -15% | -24% | -24% | -20% | -15% | - 9% | -28% |
| **Public Four-Year Enrollment** | | | | | | | | | |
| 1977 | 242 | 242 | 242 | 242 | 242 | 242 | 242 | 242 | 242 |
| 1980 | 243 | 253 | 247 | 239 | 247 | 247 | 247 | 248 | 238 |
| 1985 | 238 | 254 | 239 | 222 | 238 | 238 | 239 | 242 | 220 |
| 1990 | 235 | 247 | 230 | 200 | 224 | 225 | 230 | 237 | 195 |
| 1995 | 224 | 228 | 209 | 180 | 196 | 200 | 209 | 222 | 172 |
| 2000 | 229 | 230 | 210 | 187 | 184 | 196 | 210 | 229 | 175 |
| Low(Yr) | 224(95) | 226(97) | 207(97) | 180(95) | 184(00) | 195(98) | 207(97) | 221(96) | 171(96) |
| Percent Change | - 7% | - 7% | -15% | -26% | -24% | -19% | -15% | - 9% | -29% |

TABLE 9
MICHIGAN ENROLLMENT PROJECTIONS (Continued)

| Public, Two-Year Enrollment | Medium Economic Growth Assumptions | | | | Base Education Assumptions | | | | Pessimistic Educ. Assump. |
|---|---|---|---|---|---|---|---|---|---|
| | Constant 1977 P/R[b] | Education Assumptions | | | ZPG[d] | Low Growth | Medium Growth[c] | High Growth | Low Growth |
| | | Optimistic | Base[c] | Pessimistic | | | | | |
| 1977 | 201 | 201 | 201 | 201 | 201 | 201 | 201 | 201 | 201 |
| 1980 | 202 | 200 | 192 | 187 | 191 | 191 | 192 | 192 | 187 |
| 1985 | 197 | 195 | 181 | 175 | 180 | 179 | 181 | 183 | 173 |
| 1990 | 195 | 186 | 174 | 159 | 170 | 170 | 174 | 180 | 155 |
| 1995 | 186 | 171 | 160 | 145 | 151 | 152 | 160 | 171 | 137 |
| 2000 | 190 | 172 | 162 | 151 | 143 | 150 | 162 | 177 | 140 |
| Low(Yr) | 186(95) | 170(96) | 159(97) | 145(95) | 143(00) | 149(98) | 159(97) | 170(96) | 137(95) |
| Percent Change | - 7% | -15% | -21% | -28% | -29% | -25% | -21% | -15% | -32% |

(a) Based on simultaneous simulation of the Michigan economic and education models, under varying sets of assumptions about the behavior of their respective exogenous variables from 1978 to 2000. See Table 1 and Table 8 for details about the projection assumptions for economics and education, respectively.

(b) This assumption holds the projected 1977 age-sex specific participation rates constant through the year 2000, thus by-passing the education model.

(c) The "benchmark" projection is the medium economic growth/base education projection which is repeated here for purposes of comparison.

(d) The "so-called" ZPG projection assumes low economic growth, low births, and a three(3) percent per year growth in relative fuel prices after 1985 -- causing population to peak at 9.7 million in 1993 and decline thereafter.

rates are held constant at their 1977 levels throughout the projection period; in other words, the educational model is unplugged. The enrollments that result are shown in column one of Table 9. With participation rates constant, enrollments experience a steady-state through the early 1980's and then begin to fall. The maximum decline is seven percent, with aggregate enrollment falling by some 37,000 students from 505,000 in 1977 to a low of 468,000 in 1995. This points out rather dramatically that in the absence of any change in cohort participation patterns, the changing demographic mix of Michigan's population, as predicted by medium economic growth assumptions, will eventually result in distinct, although moderate, declines in the demand for higher education. It would take an average improvement in participation rates of up to seven percent to maintain a steady-state over the projection period. This increase in participation, should it occur, would not generate any meaningful increases in the numbers of students in Michigan's colleges and universities beyond levels experienced in the late 1970's and early 1980's.

When the enrollment model is allowed to function, individual participation rates and institutional shares change over the projection period. As a general rule under all three projection scenarios, traditional-age male participation rates tend to fall slightly at first and then maintain a steady-state, while non-traditonal males under thirty tend to increase their participation. Male participation rates over thirty also fall at first but then pick up a bit in the latter part of the century. Traditional female participation rates tend to increase steadily during the projection period mainly due to continued increases in taste for labor force participation. Non-traditional female rates on the other hand tend to fall over the projection period as the educational attainment gap closes, slowly at

first and then more rapidly later on. The net effect of these trends is for the number of female students to first equal and then exceed male students in aggregate, falling back to equality or below by the end of the century. These general trends are either augmented or dampened, depending on the particular set of education projection assumptions in question.

Looking at the impact of changing participation rates on enrollments, holding economic conditions constant (Table 9, columns 2-4), maximum declines in total enrollment range from nine percent under optimistic assumptions to twenty-four percent under the pessimistic scenario, with base assumptions generating a fifteen percent decline. If one holds base education assumptions constant, but varies economic conditions (columns 5-8), enrollments are quite similar through 1985, evidencing only small declines. The cumulative impact of different economic conditions begins to take its toll, however, and by the late 1990's, the maximum decline ranges from nine percent under high economic growth conditions to twenty percent for low growth. The even more pessimistic ZPG assumptions would produce an eventual enrollment decline of twenty-four percent, under base education projection assumptions. If low economic growth and pessimistic education assumptions are combined (column 9), total enrollment falls as much as twenty-eight percent over the 1977-2000 period. Without exception, public two-year enrollments exhibit larger proportional declines than public four-year enrollments, although the pattern of enrollment change through time is quite similar.

It should be recalled from the discussion above that the 1977 enrollment figures and the succeeding projections contain two-year college headcount enrollment that has been recently excluded from the state's official definition. Thus, there is an upward bias in the two-year projections unless one wishes

to count so-called "leisure time" enrollment. Moreover, the structural equations in the education model are not disaggregated by race. Presently, non-white participation rates are notably lower than those for whites. The medium economic projections estimate that the non-white proportion of Michigan's 18-49 year-old population will rise from 12.5 percent in 1977 to 14.7 percent in 2000. Unless the gap between white and non-white participation closes rapidly, the rising non-white share of population suggests that all the projections are biased upward to a small extent.

It is the author's inclination to accept projection assumptions which are at or below the medium/base scenarios as being "most likely" for the remainder of the century.[45] Consequently, this study would suggest that we in Michigan should expect a virtual steady-state in enrollments through the early 1980's, followed by slow and then more rapid declines through the mid-1990's, ranging, at a maximum to from 15 percent to 20 percent of present enrollment. The projection results in Table 9 suggest that, if the medium economic growth and base education assumptions are correct, baccalaureate enrollments may fall by as much as 30,000 students by the mid-1990's, while junior colleges will experience up to a 40,000 student decline. This "most likely" result, of course, derives from the opinions of the author. A salient feature of the methodology developed here is that projections can be obtained using a wide array of alternative assumptions about the model's exogenous variables, designed to suit the expectations of the model user.

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[45]It should be recalled that the medium economic assumptions reflect national growth rate estimates which are consistent with current predictions of various federal agencies and with historically-experienced trends (see Table 1).

## CONCLUSION

Forecasting the future is, of course, an imperfect science at best. The usefulness of any forecast depends critically upon the answers to two questions. First, to what extent does the forecasting model in question capture the meaningful and relatively stable causal relationships which underlie the human behavior being modeled? Second, granted a satisfactory answer to the first question, how reasonable are the projection assumptions about the exogenous variables in the model? It is the author's hope that this study provides better, although certainly less than perfect, answers than have existed heretofore.

Before summarizing the future trends projected by this study and some tentative implications of those trends, it is imperative to characterize the danger of accepting them as inevitable. No research effort can duplicate the complexitites of real world behavior or anticipate fully the unexpected. Consequently, the usual caveat applies -- those factors which have and will influence enrollment but are not explicitly treated by the study are implicitly assumed to remain constant. For example, this work neither anticipates substantial new programs for higher education nor any dramatic changes in the nature of public funding. The enrollment trends predicted here could be partially offset by new and more attractive services. Equally as well, they could be mandated or, indeed, exacerbated by reductions in funding, were those reductions to occur before, rather than after, the fact. In the end, therefore, it is the response of the "higher education system" to its own expectations about the future which will, in part, determine what is to come.

If the crystal ball employed here is less than opaque, this study suggests several important changes for higher education in Michigan in the

future. The planning and policy-making environment promises to be one of steady-state or decline, rather than growth. The two-year college -- the phenom of the sixties and seventies -- will experience enrollment pressure which may exceed that faced by the four-year schools. Intra-state relocation patterns of population will play a significant role in determining which specific two-year institutions will be stable and which will decline. At this moment in time, the possibility of major disturbances in funding sources for community education simply augments uncertainty. Baccalaureate institutions also face eventual, although perhaps less precipitous, headcount declines, although changing institutional shares could create serious problems for some institutions and little or no problem for others.

The model projections strongly suggest that the State make no significant additional investments in capacity, except in support of either unique, new programs or existing programs in extremely short supply. In either case, sufficient excess demand should be clearly in evidence. Moreover, many institutions should anticipate eventual decline in overall staffing and the need to begin the arduous task of reallocationg resources internally to meet the ever-changing mix in student demand for academic and professional skills. Those four-year institutions whose "bread and butter" is the traditional-age undergraduate would seem to face the most uncertainty. Those institutions which are not located in densely-populated areas would appear, on the surface, to be at a disadvantage with respect to the changing demographic mix of students. The severity of any enrollment decline for a given institution depends, however, on the myriad of other factors which influence the ebb and flow of inter-school patterns of enrollment and are not addressed by this research.

In sum, this study concludes that the post-war growth trend for

higher education in Michigan is virtually over. That path should level out and then fall off during the next two decades. Should a significant new baby boom develop, higher education will have sufficient lead time to erect any necessary post-2000 capacity.

# APPENDIX A

## STRUCTURAL EQUATIONS AND VARIABLE DEFINITIONS

TABLE A-1
DEFINITION OF VARIABLES
(In alphabetical order)

Type of Variable

The type of economic or demographic variable being measured is often indicated in the structural equations by a one or two letter prefix as follows:

| | |
|---|---|
| Dxxx | indicates that the variable whose abbreviation follows is a first difference (change in the variable from the preceeding year). |
| Exxx | indicates endogenous regional employment by industry, annual average of monthly estimates of number of persons employed. |
| Lxxx | indicates that the variable whose abbreviation follows is lagged by one year. |
| SHxxx | indicates exogenous U.S. value of shipments by industry in millions of constant 1972 dollars. |
| Yxxx | indicates endogenous regional income by industry of origin in thousands of constant 1972 dollars. |
| Note: | No other variables begin with the above letters. |

Industries

The income, employment, and shipments variables are disaggregated by industry as follows (in alphabetical order):

| | |
|---|---|
| CHEM | Chemicals and related industries (SIC 28) |
| CONST | Construction (SIC 15-17) |
| EXP | Aggregate of the export industries* |
| FABM | Fabricated metals (SIC 34) |
| FIRE | Finance, insurance, and real estate (SIC 60-69) |
| FURN | Furniture and fixtures (SIC 26) |
| LOSR | Aggregate of the private local-service industries* |
| MACH | Machinery, except electrical (SIC 35) |
| MV | Motor vehicles and parts (SIC 371) |
| NMFG | Aggregate of the non-manufacturing industries* |

| | |
|---|---|
| OMFG | Other non-export manufacturing industries** |
| PRIM | Primary metals (SIC 33) |
| PUB | Government--federal, state, and local |
| RT | Retail trade (SIC 52-59) |
| RUBR | Rubber and plastic products (SIC 30) |
| SERV | Services (SIC 70-89) |
| TCUT | Transportation, communication, and utilities (SIC 40-49) |
| TOT | Aggregate of all industries, public and private* |
| WT | Wholesale trade (SIC 50-51) |

*EXP = MV + MACH + PRIM + FABM + CHEM + RUBR + FURN
NMFG = CONST + TCUT + WT + RT + FIRE + SERV
LOSR = OMFG + NMFG
TOT = EXP + LOSR + PUB

**Includes, electrical machinery (SIC 36), other durables (32, 38, 39), food (20), textiles (22), apparel (23), lumber and wood products (24), petroleum (29), and other non-durables (21,31)

Endogenous Variables-Economic Model

In addition to the industry-specific employment and income variables defined above, the following variables are endogenously determined in the economic model:

| | |
|---|---|
| FORCE | Aggregate labor force aged 16 and over, annual average of monthly estimates. |
| MIGNW | Net non-white migration (calendar year) |
| MIGW | Net white migration (calendar year) |
| NATINC | Aggregate midyear population due to natural increase alone. This variable is determined in the population simulation routine by applying age- race- and sex-specific birth and survival rates to the prior year's population matrix |
| NETMIG | Net aggregate migration (midyear to midyear) determined by assuming calendar year migration is symmetrical with respect to time (see equation (43), Table A-2) |

NWP — Non-white percentage of the aggregate midyear population

PCY — Per capita real income (YTOT/POP) in constant 1972 dollars

POP — Aggregate midyear population (see equation (44), Table A-2)

$POP_{ij}$ — Element of the population matrix, the aggregate of which is the variable POP. The matrix is 4 X 86, where i are the four race-sex categories and j are 86 age categories from 0 to 85 + (see $RFORCE_{ij}$ below)

RUNR — Relative unemployment rate (ratio of Michigan/U.S. average, annual aggregate unemployment rates: U.S. Department of Labor data)

UNEMP — Number of unemployed persons (see equation (47), Table A-2)

UNRMI — Michigan unemployment rate, annual average of monthly estimates of aggregate unemployment rate

Exogenous Variables--Economic Model

These variables are underlined in the structural equations for ease of identification (see Table A-2). In addition to the industry-specific shipments variables (SHxxx) defined above, the following variables are also determined outside the economic model:

CRISIS — A dummy variable representing "crisis" associated with the 1974-75 oil embargo, and the attendant temporary shift in demand (1974-75 = 1).

EFARM — Agricultural employment in Michigan

EOTHER — Domestic and mining employment in Michigan

$RFORCE_{ij}$ — Labor force participation rate by race-sex category [i = WM(1), WF(2), NWM(3), NWF(4)] and by age [j = 16, 17, ---- 84, 85 +]

RFUEL — Relative fuel prices (ratio of average annual wholesale price index for fuel products and the GNP deflator, 1967 and 1973 = 100)

RIOT — A dummy variable representing the impact of the 1967 and 1968 Detroit riot experiences on net white migration (1967-68 = 1)

STONC — South to North Central net black migration (calendar year). Derived from estimates of the Census Bureau, Current Population Reports, Series P-20

UAW — A dummy variable representing years in which there were significant work stoppages in the automobile industry (1961, 64, 67, 70 = 1)

UNRUS — U.S. unemployment rate, annual average of monthly estimates of aggregate unemployment rate

Endogenous Variables - Education Model

RM19 — Higher education participation rate for males, ages 18-19. Computed by dividing 16-19 year-old enrollees by the 18-19 year old male population

RF19 — Higher education participation rate for females, ages 18-19. Computed in the same fashion as RM19 above.

The remaining endogenous variables are similar to the above except for the age groups used to compute the participation rates. The remaining variables are RM21, RM24, RM29, RM49, and RF21, RF24, RF29, and RF49. The age group for these male- and female- especific participation rates are:

21 ≡ ages 20-21, inclusive
24 ≡ ages 22-24, inclusive
29 ≡ ages 25-29, inclusive
49 ≡ ages 30-49, inclusive

Exogenous Variables - Education Model

AVGSD — Real, average, higher education scholarship award in Michigan, in constant 1967 dollars (deflated by Michigan's consumer price index)

BTOJ — Ratio of the average "price" of public baccalaureate to junior college education in Michigan. Based on indices of fulltime student costs (tuition, room, and board) at Michigan's fifteen four-year public institutions, and at twenty-nine public junior and community colleges(tuition only), weighted by enrollment.

COHORT — Ratio of the number of 15-24 year old persons in the Michigan population relative to the number of 25-34 year old persons.

FHUR34 (MHUR34) — Unemployment rate for females(males), aged 25-34, who have completed high school but not attended college

FLFR44 — U.S. labor force participation rate for females, aged 35-44.

GAPF — Difference or "gap" between the U.S. educational attainment of females, aged 25-34, to females aged 35-54. Educational attainment is measured by the percentage

of females in each cohort who had completed one or more years of college (based on Census Bureau data, Current Population Reports, Series P-20)

GIBILL — A dummy variable representing the impact of the legislative termination of interwar veteran's eligibility for G.I. Bill benefits as of May 31, 1976 (1974-75 = 1)

INDUCT — Number of Michigan residents inducted into the armed services (excludes voluntary enlistments)

MHUR24 — Unemployment rate for males, aged 20-24, who have completed high school but not attended college.

MHUR34 — See FHUR34

MVEED — Real education expenditures on Michigan veterans, expressed in constant 1967 dollars (deflated by Michigan's consumer price index)

PCY — Per capita real income in constant 1972 dollars, as determined in the economic model

PTOB — Ratio of the average "price" of a private higher education as compared to a public, baccalaureate education. Based on indices of fulltime student costs (tuition, room, and board) at Michigan's fifteen, four-year, public institution's and a selected sample of Michigan's private, four-year institutions, weighted by enrollment.

RPRICE — Ratio of the average "price" of a public baccalaureate education in Michigan to the average price of consumer goods (1967 = 100). Based on an index of fulltime student costs (tuition, room, and board) at Michigan's fifteen four-year public institutions and the Michigan consumer price index.

TABLE A-2
STRUCTURAL EQUATIONS -- ECONOMIC MODEL

| | | | $R^2$ | Standard Error | S.E. as a % of Mean |
|---|---|---|---|---|---|
| (1) | YMV | = 1492230 + 151.312 SHMV - 1884190 CRISIS - 6835.65 RFUEL<br>(1.89) (12.98) (-3.68) (-1.92) | .935 | 582730 | 6.7% |
| (2) | YMACH | = 1249480 + .0733688 LYMV + .583828 YFABM - 5788.57 RFUEL<br>(3.82) (2.61) (3.01) (-3.35) | .839 | 154631 | 7.2% |
| (3) | YPRIM | = 628289 + .0314099 YMV + 15.0337 SHPRIM - 3788.47 RFUEL<br>(5.06) (3.24) (5.70) (6.77) | .924 | 54626 | 4.2% |
| (4) | YFABM | = 689075 + .0955376 YMV + 12.9183 SHFABM - 4856.11 RFUEL<br>(3.85) (5.14) (2.51) (-5.24) | .916 | 90597 | 5.7% |
| (5) | YCHEM | = 393081 + .0188541 YMV + 6.06120 SHCHEM - 2037.07 RFUEL<br>(10.97) (4.31) (7.18) (-7.67) | .944 | 24596 | 4.0% |
| (6) | YRUBR | = 95418 + .0085615 YMV + 9.55830 SHRUBR - 749.99 RFUEL<br>(5.65) (4.27) (10.39) (-5.62) | .967 | 11103 | 4.5% |
| (7) | YFURN | = 48601 + 21.2157 SHFURN<br>(2.98) (11.63) | .894 | 16388 | 7.0% |
| (8) | YEXP | = YMV + YMACH + YPRIM + YFABM + YCHEM + YRUBR + YFURN | | Identity | |
| (9) | YOMFG | = 1503880 + .0397183 YEXP + .0783652 YNMFG - 3622.78 RFUEL<br>(8.20) (2.79) (6.03) (-2.97) | .921 | 104526 | 3.5% |
| (10) | YMFG | = YEXP + YOMFG | | Identity | |
| (11) | YCONS | = 647887 + 0252223 YTOTX† + 281.160 LPCY - 9570.13 RFUEL<br>(3.74) (3.90) (4.11) (-10.85) | .952 | 83587 | 4.7% |
| (12) | YTCUT | = -260599 + .0309155 YTOTX† + .448911 LFORCE<br>(-1.89) (7.50) (6.32) | .980 | 53248 | 2.2% |

TABLE A-2 (Continued)

| | | | | $R^2$ | Standard Error | S.E. as a % of Mean |
|---|---|---|---|---|---|---|
| (13) | YWT | = | -2216470 + .0248312 YTOTX† + .921204 LFORCE<br>(-6.87) (2.53) (5.55) | .941 | 127436 | 6.7% |
| (14) | YRT | = | -880415 + .0566366 YTOTX† + .672251 LFORCE<br>(-3.80) (7.91) (5.65) | .979 | 90202 | 2.6% |
| (15) | YFIRE | = | -2474410 + .0154349 YTOTX† + 1.48974 LFORCE<br>(-13.32) (2.75) (15.97) | .988 | 73644 | 2.3% |
| (16) | YSERV | = | -1263470 + .0413784 YTOTX† + 2.32502 LFORCE<br>(-16.51) (4.08) (14.75) | .987 | 129747 | 3.1% |
| (17) | YNMFG | = | YCONS + YTCUT + YWT + YRT + YFIRE + YSERV | | Identity | |
| (18) | YLOSR | = | YNMFG + YOMFG | | Identity | |
| (19) | YPUB | = | -235450000 + .919074 LFORCE + .120340 YEAR<br>(-2.95) (1.61)* (2.91) | .981 | 140550 | 3.0% |
| (20) | YTOT | = | YEXP + YLOSR + YPUB | | Identity | |
| (21) | EMV | = | 262033 + .00825422 YMV + .00865056 LYMV - 18372 UAW - 461.738 RFUEL<br>(13.89) (4.27) (5.11) (-2.45) (-4.30) | .926 | 10369 | 2.9% |
| (22) | EMACH | = | 46411 + .0307386 YMACH + .0198835 LYMACH<br>(6.21) (6.30) (4.35) | .939 | 4611 | 3.0% |
| (23) | EPRIM | = | 23843 + .0317854 YPRIM + .0222018 LYPRIM<br>(5.00) (7.18) (5.24) | .941 | 2392 | 2.5% |
| (24) | EFABM | = | 37785 + .0112197 YFABM + .0183449 LYFABM + .00472340 YMV<br>(4.27) (1.02)* (2.89) (3.54) | .897 | 5826 | 4.6% |
| (25) | ECHEM | = | 35752 + .0138505 YCHEM<br>(16.84) (4.05) | .523 | 1280 | 2.9% |

TABLE A-2 (Continued)

| | | | | $R^2$ | Standard Error | S.E. as a % of Mean |
|---|---|---|---|---|---|---|
| (26) | ERUBR | = | 5887 + .0622337 YRUBR + .0157142 LYRUBR<br>(4.53) (8.09) (2.08) | .942 | 1088 | 4.4% |
| (27) | EFURN | = | 18436 + .0283726 YFURN - 33.3639 RFUEL<br>(12.44) (5.31) (-3.39) | .701 | 963 | 4.5% |
| (28) | EEXP | = | EMV + EMACH + EPRIM + EFABM + ECHEM + ERUBR + EFURN | | Identity | |
| (29) | EOMFG | = | 123577 + .394061 LEOMFG + .00293880 YEXP - 128.413 RFUEL<br>(3.57) (3.06) (5.35) (-2.09) | .812 | 5823 | 2.3% |
| (30) | EMFG | = | EEXP + EOMFG | | Identity | |
| (31) | ECONS | = | 24018 + .0213622 YCONS + 11.1726 LPCY<br>(2.38) (3.87) (3.47) | .872 | 5296 | 4.7% |
| (32) | ETCUT | = | 89544 + .000623904 YTCUT + .0301432 LYTCUT - 179.046 RFUEL<br>(32.42) (0.18)** (8.26) (-10.01) | .976 | 1536 | 1.1% |
| (33) | EWT | = | 63890 + .0366934 YWT<br>(13.49) (15.14) | .939 | 4753 | 3.6% |
| (34) | ERT | = | 51087 + .111993 YRT<br>(1.64)* (12.67) | .915 | 20380 | 4.6% |
| (35) | EFIRE | = | 18737 + .0288444 YFIRE<br>(5.08) (25.60) | .978 | 2842 | 2.5% |
| (36) | ESERV | = | 33819 + .0894690 YSERV<br>(2.24) (25.67) | .978 | 14806 | 3.6% |
| (37) | ENMFG | = | ECONS + ETCUT + EWT + ERT + EFIRE + ESERV | | Identity | |
| (38) | ELOSR | = | ENMFG + EOMFG | | Identity | |
| (39) | EPUB | = | 28495 + .0957810 YPUB<br>(1.48)* (23.67) | .974 | 15382 | 3.2% |

TABLE A-2 (Continued)

| | | | | $R^2$ | Standard Error | S.E. as a % of Mean |
|---|---|---|---|---|---|---|
| (40) | ETOT | = | EEXP + ELOSR + EPUB | | Identity | |
| (41) | MIGW | = | 91771 - 205.403 RUNR + 6.01642 LPCY + 61.2742 STONC - 7626.9 LNWP<br>(7.92) (-4.72) (2.73) (1.56)* (-5.17) | .941 | 2441 | 23.7% |
| (42) | MIGNW | = | 207930 - 1708.27 LRUNP - .234517 LDLF - 17688 RIOT<br>(6.04) (-6.86) (-2.45) (-1.68) | .827 | 12672 | 49.5% |
| (43) | NETMIG | = | 0.5 MIGW + 0.5 LMIGW + 0.5 MIGNW + 0.5 LMIGNW | | Identity | |
| (44) | POP | = | NATINC + NETMIG | | Identity | |
| (45) | FORCE | = | $\sum_{i=1}^{4} \sum_{j=16}^{85+} (RFORCE_{ij} \cdot POP_{ij})$ | | Identity | |
| (46) | PCY | = | YTOT/POP | | Identity | |
| (47) | UNEMP | = | LF - ETOT - EFARM - EOTHER | | Identity | |
| (48) | UNRMI | = | UNEMP/FORCE | | Identity | |
| (49) | RUNR | = | UNRMI/UNRUS | | Identity | |

*Not significant at 95% level of confidence; but significant at 90% level.
**Not significant at 90% level of confidence.
†Total income(YTOT), Less income for the industry in question.

TABLE A-3
STRUCTURAL EQUATIONS -- EDUCATION MODEL

| | | | | $R^2$ | Standard Error | Mean | S.E. as a % of Mean |
|---|---|---|---|---|---|---|---|
| (1) | RM19 | = | 29.74 + .0246299 INDUCT + 8.47270 COHORT<br>(6.26) (5.57) (2.29) | .777 | 1.99 | 44.24 | 4.5% |
| (2) | RM21 | = | -8.50 + .3227 LRM19 + .0214156 INDUCT + 23.7592 COHORT<br>(-1.08)* (1.35)* (3.55) (3.72) | .896 | 2.05 | 40.62 | 5.0% |
| (3) | RM24 | = | 1.29 + .0013787 PCY + .209753 MHUR24 + .2891 RM21<br>(0.40)** (1.48)* (1.62)* (3.11) | .743 | 1.53 | 20.72 | 7.4% |
| (4) | RM29 | = | 1.06 + .0200892 MVEED + 1.75 GIBILL + .00199711 PCY<br>(0.64)** (2.71) (2.45) (5.06) | .904 | 0.71 | 10.85 | 6.5% |
| (5) | RM49 | = | 0.11 + .0157984 MVEED + 0.88 GIBILL + .0002950 PCY<br>(0.25)** (7.03) (7.39) (3.31)<br>+ .0760137 MHUR34<br>(2.26) | .990 | 0.12 | 2.35 | 5.1% |
| (6) | RF19 | = | 4.44 + .52549 FLFR44 + .0102878 AVGSD<br>(0.77)** (4.04) (3.15) | .871 | 1.61 | 33.52 | 4.8% |
| (7) | RF21 | = | -18.43 + .3303 LRF19 + .5500 FLFR44 + .042205 AVGSD<br>(-5.29) (2.32) (4.66) (1.81) | .958 | 0.97 | 21.21 | 4.6% |
| (8) | RF24 | = | -22.96 + .685845 FLFR44 + .025336 AVGSD - 4.16720 RPRICE<br>(-6.87) (15.56) (1.92) (-1.71)* | .979 | 0.53 | 7.65 | 6.9% |
| (9) | RF29 | = | 4.91 + .000425 PCY - 6.76612 RPRICE + .58397 GAPF<br>(2.67) (1.37)* (-2.40) (16.67) | .976 | 0.36 | 4.27 | 8.4% |
| (10) | RF49 | = | 4.05 + .0001831 PCY - 5.8787 RPRICE + .295515 GAPF<br>(4.76) (1.47)* (-5.13) (16.40)<br>+ .105554 FHUR34<br>(3.94) | .987 | 0.14 | 1.84 | 7.6% |

TABLE A-3 (Continued)

| | | | | | $R^2$ | Standard Error | Mean | S.E. as a % of Mean |
|---|---|---|---|---|---|---|---|---|
| (11) | VSHARE = | 54.37 (17.88) | - 17.9345 PTOB (-9.18) | - 13.0150 RPRICE (-2.60) | .961 | .72 | 15.72 | 4.6% |
| (12) | BACP = | 65.76 (11.18) | - 1.74242 BTOJ (-1.92) | - .0274628 MVEED (-1.78) | .992 | .82 | 67.66 | 1.2% |

*Not significant at the 95.0% level of confidence, but significant at the 90.0% level.
**Not significant at the 90% level of confidence.


115

# APPENDIX B

## DEMOGRAPHIC METHODOLOGY

In order to forecast the demand for education for Michigan it is necessary to obtain detailed annual forecasts of the civilian-non-institutional population by single year of age, by race (white or non-white) and by sex (male or female). For this purpose, the economic-demographic model developed in this study includes a highly disaggregated demographic routine which estimates two 86 x 4 population matrices for each year -- one for the resident population and one for the civilian non-institutional population.[1] These data are not available except at each dicennial census and, therefore, they must be estimated for each year of the 1960 to 1977 data period except 1960 and 1970. That estimation process must also be converted to a projection methodology and used iteratively throughout the projection period (1978-2000).

The demographic estimation process begins with known demographic data -- the detailed 1960 and 1970 Michigan census counts and related information, actual annual births and mortality rates for 1960 to 1977, and mid-year aggregate resident population estimates for each inter-censal year. Basic data was obtained from the 1960 and 1970 Censuses of the population, the Michigan Department of Public Health, and the Bureau of the Census's inter-censal population estimates.[2] The State's vital events records yield

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[1] Each matrix consists of 86 rows (single year age groups from 0-1 to 84-85 plus one additional aggregated categor , 85 and over) and four columns (major race-sex groups -- white male, white female, non-white male, non-white female). Resident Population includes both resident military personnel and institutionalized civilians, while the civilian-non-institutional population excludes both types of persons.

[2] Current Population Reports, Series P-25 and P-26 have periodically provided mid-year population estimates, based on an average of estimates obtained by three alternative methods: (1) regression estimates based on elementary school enrollments, automobile registrations and other symtomatic data; (2) Census Bureau's Component Method II using births, deaths, and school enrollment to measure each population component separately, and (3) Administrative Records method using IRS data. These estimates have been made jointly by Bureau of the Census and State agencies since 1970. See Moor (37), Morrison (34), and Bureau of the Census (9) for details.

sex and race-specific live births and life tables from which disaggregated survival rates for successive five-year cohorts are computed. For purposes of moving the population through time on an annual basis, these five-year data are converted to single-year survival rates by computing the compound annual survival rate necessary to generate the observed five-year survival experience.

The annual net migration estimates by race is the most difficult to derive, since most disaggregated region-specific migration data is either cross-sectional data gathered at each Census point or ten-year census-survival estimates of net migration from Census to Census. Neither give an indication of the annual variations in gross migration flows (i.e., inmigration and outmigration) which are so closely related to the time path of regional economic conditions. An additional problem is that the annual population estimates are aggregate, rather than race-specific. All evidence indicates that the historical pattern of non-white migration has been significantly different from that of white migration for the North Central region and for Michigan in particular, necessitating disaggregation by race.

The latter problem is overcome by making annual inter-censal estimates of the non-white percentage of the population. The 1960 and 1970 proportions by race are easily derived from Census data. The 1975 midyear percentage can be closely estimted based on recorded vital events from April 1, 1970 to July 1, 1975 and on recently estimated state population and migration estimates by race for the 1970-75 period, prepared by the Bureau of the Census (50). Annual midyear estimates for 1961-1969, 1971-1974, and 1976-1977 are obtained by fitting an exponential curve to the known points in order to approximate a time-series for the non-white proportion of the

population. These estimates are then used to divide the annual population estimates into their white and non-white components.

Annual net migration estimates by race are then obtained by applying the census-survival methodology, beginning with the 1960 Census population matrix. The age-sex and race-specific single year survival rates are applied to each age (row) of the population matrix to reflect mortality experience, the survivors aged one-year, and the surviving live births added to the now empty first row. The resulting matrix is the estimated 1961 population, assuming zero gross migration flows from 1960 to 1961. Aggregating the matrix to obtain white and non-white population totals and comparing those totals to the racially-disaggregated Census Bureau population estimates yields a race-specific net-migration estimate from midyear to midyear.

In order to derive the next year's migration estimates, however, the in-migrants and out-migrants must be added and subtracted, respectively, from the existing matrix of population, which at that point only includes change due to natural increase. This is accomplished in part by using both 1960 and 1970 Census data on migration patterns for Michigan to estimate the age-race-sex distributions of the gross migration flow.[3] Based on this data, out-migration is estimated as a proportion of each respective age-race-sex specific resident population cohort, aggregated, and then added to the net-migration estimate to obtain an aggregated estimate of gross in-migration. This estimate of the in-migration flow is then disaggregated based on the appropriate age-race-sex specific Census distribution. The 86 x 4 matrices of out-migration and in-migration are then subracted and added to the

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[3]The Census ask respondents where they were living five years prior to their reported address and then estimate disaggregated gross in-migration and out-migration flows over that period by age, race, and sex for states and sub-strate areas.

existing matrix of resident population to obtain the final 1961 population matrix itself. In addition, a subroutine is developed to account for Michigan residents who were shipped overseas by the military, a problem which especially distorted the Viet Nam period. Additionally, another subroutine is used to convert the resident population matrix to a civilian-non-institutional population matrix, based on historical relationships obtained from Census data and other sources.

The same procedure is iterated for each year between 1960 and 1970. This process yields annual, midyear to midyear net migration estimates by race and annual 86 x 4 population matrices adjusted for both migration and vital events. The total population for each year, of course, is identical to the Bureau of Census estimate. A similar iteration is performed from 1970 to 1977 using the actual 1970 Census population matrix as the starting point. The 1977 population matrix thus derived becomes the base year population matrix for all projections. The accuracy of this approach to generating disaggregated annual population and migration estimates can be partially assessed by comparing the estimated 1970 population matrix to the 1970 Census matrix. While part of the difference between the two is explained by error in Census estimates themselves between 1960 and 1970, the results of this comparison, as summarized in Table B-1, are encouraging. Based on comparisons of five-year cohorts by race and sex, deviations range from virtually no error to 7.3 percent, the average (absolute) deviation ranging from 2.8 percent for non-white males to 1.1 percent for white females. The highest percentage errors occur in the older cohorts (55 and over), especially for non-whites where there appears to be consistent underestimation. Over two-thirds of the race- and sex-specific cohorts deviate less than two percent from the Census matrix; only five of forty-eight exceed three percent.

TABLE B-1
PERCENTAGE DEVIATION
SIMULATED POPULATION OVER/(UNDER) ACTUAL CENSUS COUNT
1970 POPULATION MATRIX

| Age Cohort | White Male (WM) | White Female (WF) | Non-White Male (NWM) | Non-White Female (NWF) |
|---|---|---|---|---|
| 0- 4 | 1.63% | 1.60% | 2.77% | 0.03% |
| 5- 9 | ---- | 0.46 | 0.63 | (2.83) |
| 10-14 | (1.17) | (1.19) | (0.19) | 1.05 |
| 15-19 | (1.87) | (1.69) | 1.73 | 3.01 |
| 20-24 | (1.48) | (1.11) | (2.47) | (1.33) |
| 25-29 | (1.19) | 0.18 | (0.31) | (1.28) |
| 30-34 | 2.62 | 2.57 | 6.12 | 2.40 |
| 35-39 | 2.34 | 2.77 | 5.10 | 2.44 |
| 40-44 | 0.43 | 0.21 | (1.29) | 0.49 |
| 45-54 | (0.24) | (0.54) | (0.30) | 1.65 |
| 55-64 | 0.85 | 0 41 | (5.27) | (2.56) |
| 65 and over | 0.64 | (0.30) | (7.27) | (5.54) |
| Average* | 1.21% | 1.09% | 2.79% | 2.05% |

*Based on absolute value of percentage, not weighted by size of cohort.

Last the simulation routine estimates the civilian labor force using actual U.S. labor force participation rates, adjusted for U.S./Michigan differentials derived from the 1970 Census. The derived participation rates are multiplied times their respective age, race, and sex-specific cohorts of the civilian non-institutional population, aged 16 and over, to obtain the labor force. Table B-2 presents both the calendar year net migration estimates by race and the midyear labor force estimates for the 1960 to 1977 data period. The labor force figures are very close to those estimated by the MESC for 1970-77, varying by no more than one percent in any year. The 1960-69 MESC estimates are also shown, but they are unofficial and not comparable to their 1970-77 estimates nor to the estimates obtained from the population simulation. The "actual" net migration figures are those obtained from the population simulation. The "estimated" net migration figures are those obtained from the structural equations (see Table A-2, equations 41 and 42).

The simulation methodology is adapted to the projection routine with three major changes. First, since actual births are used to generate the number of live births for each projection year. Table B-3 summaries historical birthrate experience for Michigan and highlights the high, medium, and low projection assumptions. The projection routine uses completed fertility rates by race and age of mother for five-year cohorts from 10 - 50 years of age. Table B-3 presents the weighted summation of these completed fertility rates. Second, the most recent mortality change factors estimated by the Census Bureau for 1978-2000 are used to adjust survival rates during the projection period. Finally, labor force participation rates by age, race and sex were projected based on Department of Labor sources.[4]

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[4]See footnote 29 in the text for references on mortality change factors and/or labor force participation rate projections.

TABLE B-2
NET MIGRATION AND LABOR FORCE SIMULATIONS
ACTUAL VERSUS ESTIMATED--1960-1977
(In Thousands of Persons)

| Calendar Year | Net Migration[a] White | | | Net Migration[a] Non-White | | | Civilian Labor Force[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Actual | Est. | Est. +/- Actual | Actual | Est. | Est. +/- Actual | Actual | Est. | Est. +/- Actual |
| 1960 | -80 | n/a | n/a | 8 | n/a | n/a | 2959 | 3003 | N/A |
| 1961 | -85 | -81 | 4 | 8 | 10 | 2 | 2954 | 2996 | N/A |
| 1962 | -46 | -48 | - 2 | 13 | 11 | - 2 | 2939 | 2982 | N/A |
| 1963 | - 5 | - 6 | - 1 | 19 | 20 | 1 | 2967 | 3033 | N/A |
| 1964 | 22 | 34 | 12 | 22 | 21 | - 1 | 3070 | 3094 | N/A |
| 1965 | 43 | 26 | -17 | 24 | 22 | - 2 | 3211 | 3182 | N/A |
| 1966 | 24 | 27 | 3 | 21 | 22 | 1 | 3369 | 3282 | N/A |
| 1967 | -11 | - 4 | 7 | 16 | 14 | - 2 | 3451 | 3362 | N/A |
| 1968 | -24 | -31 | 7 | 14 | 11 | - 3 | 3501 | 3421 | N/A |
| 1969 | 1 | - 8 | 9 | 17 | 15 | - 2 | 3594 | 3508 | N/A |
| 1970 | - 7 | - 9 | - 2 | 8 | 8 | -- | 3596 | 3580 | -16 |
| 1971 | -25 | -26 | - 1 | 2 | 2 | -- | 3621 | 3657 | 36 |
| 1972 | -34 | -18 | 16 | 1 | 3 | 2 | 3700 | 3720 | 20 |
| 1973 | -10 | -25 | -15 | 8 | 7 | - 1 | 3807 | 3809 | 2 |
| 1974 | -30 | -18 | 12 | -- | 4 | 4 | 3883 | 3908 | 25 |
| 1975 | -51 | -36 | 15 | - 2 | - 7 | - 5 | 3901 | 3943 | 42 |
| 1976 | -40 | -47 | - 7 | -- | -- | -- | 3999 | 4010 | 11 |
| 1977 | -34 | -24 | 10 | 1 | 3 | 2 | 4118 | 4097 | 21 |

[a] Actual values for net migration are those determined by the 1960-1977 population simulation converted from a fiscal year to a calendar year basis by assuming the net migration flows were symmetrical. Estimated values are the fitted values obtained by using the structural equations within the data period, 1960-1977.

[b] Actual figures from Michigan Employment Security Commission are not comparable for 1960-1969 and 1970-77, due to a change in estimation technique. Estimated values are computed using the 1960-1977 population simulation, adjusted for military and institutionalized civilians. Labor force is estimated by applying age and sex-specific U.S. civilian labor force participation rates adjusted for Michigan/U.S. differentials computed from 1960 amd 1970 census data.

TABLE B-3
MICHIGAN BIRTHRATE EXPERIENCE AND PROJECTIONS

| Completed Fertility Rate (per 1,000 Women) | Actual[a] | | | | | Alternative Projection Assumptions[b] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | High | | Medium | | Low | |
| | 1960 | 1965 | 1970 | 1975 | 1977 | 1990 | 2000 | 1990 | 2000 | 1990 | 2000 |
| White | 379 | 299 | 247 | 166 | 167 | 210 | 250 | 210 | 210 | 167 | 167 |
| Non-White | 409 | 313 | 312 | 231 | 225 | 259 | 290 | 225 | 225 | 216 | 210 |
| Aggregate | 382 | 301 | 256 | 172 | 174 | 217 | 256 | 212 | 212 | 174 | 173 |
| **Crude Birthrate (per 1,000 Population)** | | | | | | | | | | | |
| White | 25 | 20 | 18 | 14 | 14 | 17 | 17 | 17 | 16 | 14 | 12 |
| Non-White | 29 | 23 | 27 | 21 | 21 | 23 | 23 | 20 | 18 | 19 | 17 |
| Aggregate | 25 | 20 | 19 | 15 | 15 | 18 | 18 | 18 | 15 | 15 | 13 |
| **Number of Births (000)** | | | | | | | | | | | |
| White | 173 | 146 | 144 | 110 | 114 | 148 | 161 | 148 | 135 | 118 | 106 |
| Non-White | 22 | 21 | 28 | 24 | 24 | 32 | 36 | 28 | 28 | 26 | 26 |
| Total | 195 | 167 | 172 | 134 | 138 | 180 | 197 | 176 | 163 | 144 | 132 |
| **Population(000)** | | | | | | | | | | | |
| White | 7097 | 7470 | 7859 | 7981 | 7974 | 8636 | 9266 | 8638 | 9130 | 8442 | 8701 |
| Non-White | 737 | 887 | 1042 | 1130 | 1155 | 1408 | 1588 | 1388 | 1529 | 1378 | 1502 |
| Total | 7834 | 8357 | 8901 | 9111 | 9129 | 10044 | 10854 | 10026 | 10659 | 9820 | 10203 |

[a] Births: Michigan Department of Public Health / Population: Census Bureau estimates and 1960-77 population simulation. 1960 and 1970 statistics are based on Census population counts rather than on July 1 estimates.

[b] Projection assumptions are boxed. Estimates and weighted averages are based on medium economic growth and relative fuel price assumptions.

# APPENDIX C

## HOUSEHOLD DEMAND FOR HIGHER EDUCATION

The work of Gary Becker (3,4,5) is part of a growing literature which treats the behavior of a household much like the behavior of the firm -- combining traditional consumer demand theory with production theory to explain household behavior, including marriage, family size, labor force participation, state of health, acquisition of human capital, leisure, and so on. In this formulation, households are both utility maximizers and efficient production units, combining own-time with market goods (and services) over the life-cycle to produce non-market commodities which yield direct utility to the households. What follows is an adaptation of this approach, beginning with some basic definitions:

$Z_{ik}$ = the $i^{\underline{th}}$ non-market commodity produced by the $k^{\underline{th}}$ household, for $i = 1,2,.....n$.

$X_{ik}$ = the market-basket of goods (and services) which are purchased with household money income and serve as inputs to the production of $Z_{ik}$.[1]

$T_{ik}$ = the amount of $k^{\underline{th}}$ household's own-time devoted to the production of $Z_{ik}$, where own-time is all time not spent working (i.e., generating money income).

The $k^{\underline{th}}$ household is thought to have n production functions of the form,

$$(1) \quad Z_{ik} = f_{ik}(X_{ik}, T_{ik}; E_k)$$

where $E_k$ represents the "state of the world" within which the $k^{\underline{th}}$ household produces, that is, the exogenous environmental and/or institutional variables which potentially influence household production.[2] Further, define a household

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[1] More appropriately, both $X_{ik}$ and $T_{ik}$ should be vectors of goods and own-time, since different kinds and relative amount of goods and time are devoted to the production of each $Z_{ik}$. Scalers are used for the sake of simplicity. In addition, if any of the goods represented by $X_{ik}$ are durable goods, then $X_{ik}$ measures the stream of services derived from such goods over the relevant time period.

[2] $E_k$ and, as introduced below, $D_k$ are likewise entered as scalers for the sake of simplicity, when, in fact, they are vectors of environmental and taste variables.

utility function $U_k$, as follows, where $D_k$ is constant in the short-run and

$$(2)\quad U_k = U_k (Z_{1k}, Z_{2k}, \ldots Z_{nk}; D_k) = U_k (Z_{ik}; D_k)$$

represents the state of the household's tastes and preferences for the various $Z_{ik}$.[3] The $k^{\underline{th}}$ household maximizes $U_k$ subject to the joint constraints of own-time and market goods available as inputs. Total time available ($T_k$) is divided between working-time ($T_{wk}$) and household production time ($T_{ik}$).

$$(3)\quad T_k = \sum_{i=1}^{n} T_{ik} + T_{wk}$$

letting $Y_k$ be total money income received by the $k^{\underline{th}}$ household, $W_k$ be the appropriate net market wage rate, and $R_k$ be the flow of non-wage income derived from non-human household wealth, the goods constraint becomes

$$(4)\quad Y_k = W_k T_{wk} + R_k = \sum_{i=1}^{n} P_i X_{ik}$$

where $P_i$ is the market price of $X_{ik}$. Both $P_i$ and $W_k$ are exogenous to the household.[4]

The time and goods constraints are not independent, however, because time can be converted to goods by allocating more own-time to market work and less to household production and <u>vice-versa</u>. Combining (3) and (4), one gets

$$(5)\quad \sum_{i=1}^{n} (P_i X_{ik} + W_k T_{ik}) = W_k T_k + R_k = S_k$$

where $S_k$ is defined as the "full-income" constraint for the $k^{\underline{th}}$ household,

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[3] It is assumed, them, that the $k^{\underline{th}}$ household's tastes and preferences for goods are entirely derived from its tastes for the non-market commodities ($Z_{ik}$) it produces, and no utility is derived solely and uniquely from the market purchase of goods.

[4] In addition, it is assumed for the sake of simplicity that $W_k$ is invarient across all increments of time and thus across all commodities, $Z_{ik}$. This is unlikely to be the case, however, because the opportunity cost of time differs depending on which person and what portion of the day or week are involved. Again, vector notation would be necessary to capture this complicating factor.

which includes not only wage income ($W_k T_{wk}$) and non-wage income ($R_k$), but also the opportunity cost of own-time devoted to household production of the various $Z_{ik}$ ($W_k \sum_{i=1}^{n} T_{ik}$).

Maximizing household utility (2), subject to the full-income (time and goods) constraint (5) results in a Lagrangian problem of the usual form:

$$(6) \quad L_k = U_k (Z_{ik}; D_k) - \lambda \left[ \sum_{i=1}^{n} (P_i X_{ik} + W_k T_{ik}) - S_k \right]$$

but since, from (1), each $Z_{ik}$ is also constrained by its production function, (6) becomes

$$(7) \quad L_k = U_k \left[ f_{ik}(X_{ik}, T_{ik}, E_k); D_k \right] - \lambda \left[ \sum_{i=1}^{n} (P_i X_{ik} + W_k T_{ik}) - S_k \right]$$

where $\lambda$ is the Lagrangian multiplier, usually interpreted to be the marginal utility of full-income. Assuming that both $E_k$ and $D_k$ are constant and that $U_k$ and $f_{ik}$ are twice-differentiable and strictly concave over their relevant ranges, then the first-order conditions which are necessary for utility maximization are:

$$(8a) \quad \frac{\partial U_k}{\partial f_{ik}} \cdot \frac{\partial f_{ik}}{\partial X_{ik}} - \lambda P_i = 0 \qquad \text{for } i = 1,2,....n$$

$$(8b) \quad \frac{\partial U_k}{\partial f_{ik}} \cdot \frac{\partial f_{ik}}{\partial T_{ik}} - \lambda W_k = 0 \qquad \text{for } i = 1,2,....n$$

$$(8c) \quad \frac{\partial U_k}{\partial \lambda} = \sum_{i=1}^{n} (P_i X_{ik} + W_k T_{ik}) - S_k = 0$$

If (8a) and (8b) are solved for $\lambda$ in the case of each $Z_{ik}$, one gets

$$(9) \quad \frac{MPX_{ik}}{MPT_{ik}} = \frac{P_i}{W_k} \qquad \text{for } i = 1,2,....n$$

where $MPX_{ik} = \partial f_{ik}/\partial X_{ik}$ is the marginal product of $X_{ik}$ in the production of $Z_{ik}$, and likewise for $T_{ik}$. Therefore, utility maximization requires that

the first order conditions for output miximization (least-cost production) hold. In other words, consumer equilibrium implies that the most efficient (least-cost) combination of goods and time will be allocated to the production of the utility maximizing bundle of $Z_{ik}$.

Differentiating (6) with respect to each commodity we can derive the equilibrium ratio of marginal utilities of any two commodities $Z_{ik}$ and $Z_{jk}$ to be:

$$(10)\quad \frac{MUZ_{ik}}{MUZ_{jk}} = \frac{P_i \frac{dX_{ik}}{dZ_{ik}} + W_k \frac{dT_{ik}}{dZ_{ik}}}{P_i \frac{dX_{jk}}{dZ_{jk}} + W_k \frac{dT_{jk}}{dZ_{jk}}} = \frac{\pi_{ik}}{\pi_{jk}} \qquad \text{for } i, j = 1,2,\text{----}n$$

where $\pi_{ik}$ is the marginal cost of $Z_{ik}$ and the derivatives in (10) are the marginal input-output coefficients derived from the production function, $f_{ik}$. A change in any $Z_{ik}$ therefore, releases or claims an incremental portion of $S_k$, which in turn releases or claims marginal inputs of goods and own-time to be reallocated to or recovered from the production of all commodities. The shadow price of any commodity $Z_{ik}$ is the per unit marginal cost of its production and depends on the prices of goods and time and the marginal productivity of each.

Solving the 2n + 1 first-order conditions of (8) for 2n + 1 unknowns ($X_{ik}$, $T_{ik}$,$\lambda$) results in derived demand functions for goods and time of the form.

$$(11)\quad \hat{X}_{ik} = x_{ik}(P_1, P_2, \text{---}P_i, \text{---}P_n, W_k, R_k, D_k, E_k)$$

$$(12)\quad \hat{T}_{ik} = t_{ik}(P_1, P_2, \text{---}P_i, \text{---}P_n, W_k, R_k, D_k, E_k)$$

for all i = 1,2,----n. $\hat{X}_{ik}$ and $\hat{T}_{ik}$ are the equilibrium quantities of goods and time, respectively. The demand functions for goods (11) differ from the traditional analysis of consumer demand only in the fact that they explicitly include time and thus full-income as a constraint and separate the catch-all variable

"tastes" into two separate categories (1) those psychological preferences, ($D_k$) which directly impact the utility function by changing the satisfaction (marginal utility) derived from a given combination of $Z_{ik}$, and (2) those environmental and/or institutional conditions ($E_k$) which influence the production function by directly effecting the productivity of one or both inputs. Of course, a change in either $D_k$ or $E_k$ could indirectly effect the production of $Z_{ik}$ through their influence on good's prices or wages as well.

In order to derive an aggregate demand curve for any market good, $X_i$, it is necessary to "add-up" the demand functions (11) for all households, k = 1,2, ----m.

$$(13) \quad \sum_{k=1}^{m} X_{ik} = \sum_{k=1}^{m} x_{ik} (P_1, P_2, ---P_i, ---P_n, W_k, R_k, D_k, E_k)$$

To do this we assume that household tastes and perceptions ($D_k$ and $E_k$) are independent and, as before, that households are price-takers in both goods and labor markets. The resulting equilibrium aggregate demand for any good ($\hat{X}_i^*$) becomes

$$(14) \quad X_i^* = X_i(P_1, P_2, ---P_i, ---P_n; \bar{W}; R^*, \bar{D}, \bar{E})$$

where $\bar{W}$, $\bar{D}$, and $\bar{E}$ are weighted average indices of wages, tastes, and environmental/institutional conditions, respectively, and R* is aggregate non-wage income, all of which are constant in the short-run. Therefore, the demand for any good $X_i$ is a function of (1) own-price, (2) the prices of substitutes and compliments in production, (3) full-income ($\bar{W}\sum_k T_k + R^*$), (4) household tastes, and (5) productivity influencing changes in the household's environment. While, as mentioned above, this demand function is not truly different from the more traditional function, it does emphasize the complimentary role played by time in household behavior, separate pure changes in taste from changes in environmental or institutional variables

which effect the "productivity" of goods and time in household consumption, and highlight the complimentarity or substitutability between commodities like educational attainment, labor force participation, fertility, health and leisure, which are not really market goods in the traditional sense of the term. A change in relative input prices effects, in turn, both the allocation of full-income and the relative shadow prices of all $Z_{ik}$. Therefore, changes in the amount of $X_{ik}$ demanded depend ultimately on the own and cross-elasticities of demand among the various $Z_{ik}$.

The particular market good in question in this study is $X_f$, formal enrollment at institutions of higher education, which is normalized for the most basic demographic differences by using age and sex-specific participation rates. $X_f$ is utilized in combination with household own-time to "produce" $Z_h$, which is post-secondary education defined in its broadest sense to mean the acquisition of post-secondary human capital, not just college-going, per se. Formal enrollment in college, then, is but one of several market goods which can be purchased with money income and combined with own-time as a means of producing $Z_h$. Other means, which are denoted in aggregate as $X_g$ below, might be union apprenticeship, trade school, co-op programs (or other formal on-the-job-traning arrangements), correspondence courses, military or religious service, and the like.

Assuming for simplicity that $X_f$ and $X_g$ are the only two goods available as inputs into the household production of $Z_h$, then the production function (1) becomes:

$$(15) \quad Z_h = f(X_f, X_g, T_f, T_g, E)$$

and there is a derived aggregate demand for formal enrollment of the form,

$$(16) \quad \hat{X}_f = X_f (P_1, P_2, \ldots P_f, P_g, \ldots P_n, \overline{W}, R^*, \overline{D}, \overline{E})$$

There are similar derived demand function for $X_g$, $T_f$, and $T_g$ as well. By

incorporating the notion of household production into the demand for higher education, it is implied that demand does not merely respond to the usual money income and relative price changes, but responds as well, to (1) changes in the relative shadow prices of the non-market commodities, $Z_i$, (2) to changes in the productivity of goods and time, and (3) to changes in full-income as the household seeks to attain a utility maximum and, simultaneously, to achieve least-cost production.[5] Further, as noted above, consumer tastes are subdivided into preferences for non-market commodities and into various environmental/ institutional variables which reflect the state of the world within which household production takes place.

If input prices are held constant, an increase in the marginal product of some input will generate several responses. First, to minimize production costs, the input in question will be more intensively utilized relative to other factors, i.e., substitution in production will take place wherever possible. Since the relative shadow price of those commodities using the input are reduced, the usual income and substitution effects in consumption will also occur. The net effect on the demand for the input will rise if the combined income and substitution effects out weigh the productivity gain. The change in productivity is most likely caused by a change in household environment, E. For example, in this study the variables COHORT AND GAPF represent demographic changes over time which directly influence the perceived productivity

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[5]It is instructive to note that the two-year college may be popular simply because it allows more freedom in the simultaneous use of other market goods and time in the pursuit of broadly-defined post-secondary "education." More than likely, however, the two-year institution has been successful because its lower costs in terms of time and money income have allowed a greater portion of household resources to be allocated to non-market commodities which do not require inputs as indivisible as college-going and yield higher utility per full-income dollar (e.g., labor force participation, leisure time, child-rearing, etc.).

of formal higher education.[6] Increases in productivity result in greater use of formal enrollment in the production of post-secondary education.

Holding productivity constant, a reduction in the relative price of some input will shift production toward commodities that use that input more intensively. The greater the related elasticities of substitution in production and consumption, the greater will be the increase in demand for that input. Such a price change can come about directly through changes in either D or E. For example, if the political or demographic climate alters public subsidies to college-going, then the amount of $X_f$ and $Z_h$ will be effected because of the relative price change for $X_f$. In this study, declining veterans expenditures on higher education (MVEED) has a negative impact on $X_f$, while rising state scholarship grants (AVGSD) have a positive impact.

On the other hand, changes in tastes (D) for household-produced commodities, influence the amount of $X_f$ purchased by first influencing the relative amount of $Z_h$ desired by the household, that is, by changing the marginal utility of $Z_h$ itself. The resulting adjustment of the relative amounts of commodities produced and consumed and the accompanying reallocation of goods (including $X_f$) and time are determined by the various price and income elasticities of demand and the elasticities of substitution in production. For example, in this study the variable FLFR44 is used to capture changing tastes on the part of women for labor force participation versus own-time household production. The increase in demand for higher education associated with this "taste change" emanates from a complimentary relationship between labor force participation and educational attainment, both commodities that are produced and "consumed" by the household.

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[6]The educational attainment gap between older and younger women (GAPF) and the relative cohort size for younger men (COHORT) simultaneously reflect the strong complimentarity between post-secondary education and labor force participation, and in the case of older women, their dramatic change in taste for market work.

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